WINE SPRING CREEK

ECOSYSTEM MANAGEMENT PROJECT

SUMMARY OF RESEARCH RESULTS FROM:

COWEETA HYDROLOGIC LABORATORY

RESEARCH

EDUCATION COOPERATION

DEMONSTRATION CONSULTATION

SERVICE

ESTABLISHED - 1934

COWEETA HYDROLOGIC LABORATORY
SOUTHERN RESEARCH STATION
FOREST SERVICE, USDA
3160 COWEETA LAB ROAD
OTTO NC 28763

ASSESSMENT OF EXISTING AND FUTURE STREAM CONDITIONS

1. Flow volumes, storm peaks, and precipitation:
   Cross-section gaging.

2. Stream temperature:
   Daily mean and range.

3. Aquatic biology.

4. Storm and background suspended sediment concentration:
   Tools to estimate loading from limited TSS samples.

5. Storm bedload movement:
   Sediment traps,
   Riffle stability index,
   Nelson's bedload movement model.

6. Storm and background water chemistry.

7. Monitoring effect of management activities:
   Evaluation,
   Validation.

8. Predictive management guide on GIS platform:
   Identify potential sediment sources,
   Estimate terrestrial transport and deposition of sediment,
   Estimate potential impact of sediment sources on streams.

Project Goals

- Demonstrate Ecosystem Management
- Guided by Desired Future Conditions
- Implement Monitoring
- Integrate Management & Research
- Test Technology in Application
- Contribute to decision support system

Wine Spring Creek Ecosystem Management Project

An ecosystem management project has been implemented on a 4420 acre basin on National Forest land in western North Carolina. The project encompasses an interdisciplinary partnership of social scientists, aquatic and terrestrial ecologists, resource managers, conservation and environmental groups, and the public.

The objective of the project is to use and/or develop ecologically based concepts, principles, and technology to achieve desired resource conditions. The approach uses the Land and Resource Management Plan to identify basic management emphases and standards for the project area which form the framework for assessing desired resource conditions through interactive planning workshops with potential partners. Prescriptions used to achieve each desired condition are then considered in the context of existing data, exploratory/inventory activities, and research/manipulations/monitoring.

Desired resource conditions were developed over an 18 month period through workshops involving invited representative from a variety of organizations, including terrestrial and aquatic scientists from six Research Work Units in the Southern Research Station and four Universities; Federal & State land managers; Western North Carolina Alliance; Bartram Trail Society; Trout Unlimited; The Ruffed Grouse Society; and The National Wild Turkey Federation. Additional public input was incorporated into the project during the NEPA process.

From this consensus building process, 35 desired resource conditions, many which are not mutually exclusive, were initially identified for the project area. The stated desired conditions implicitly and explicitly entail a variety of technology transfer opportunities and ecosystem research needs. Thus, in the first year of the project, 27 studies were initiated with a major emphasis on inventory/exploratory activities. Melding of desired conditions with research and technology transfer generated the following themes for the project area:

- ☞ Ecological Classification
- ☞ Riparian Zone Management
- ☞ Aquatic Productivity/Water Quality/Habitat Alteration
- ☞ Sustainable Productivity (Regeneration, Biodiversity, and Biogeochemical Cycles
- ☞ Social and Amenity Value Assessment
- ☞ Restoration of Degraded Forest Communities
- ☞ Mammal & Bird Population Dynamics
- ☞ Special Ecosystems ("Balds")

Wine Spring Creek Ecosystem Management Project

The Wine Spring Creek Project is an ecosystem management demonstration project on the Wayah Ranger District, Nantahala National Forest, Macon County, North Carolina. The 4,400 acre project area is situated between Nantahala Lake (elevation: 3,000 feet) and Wine Spring Bald (elevation: 5,430 feeet), and constists of the entire watershed of Wine Spring Creek, along with National Forest lands in several smaller adjacent drainages.

The objective of the project is to use and/or develop ecologically based concepts, principles, and technology to achieve desired resource conditions. The project encompasses an interdisciplinary partnership of aquatic and terrestrial ecologists, social scientists, resource managers, conservation and environmental groups, and the public.

The Wine Spring Creek project was conceived in a series of meetings during 1991 and 1992 between Forest Service managers and researchers, university researchers, North Carolina Wildlife Resources Commission personnel, and specific user groups such as Trout Unlimited, the Ruffed Grouse Society, the National Wild Turkey Federation, and the Bartram Trail Society. Following the development of site specific desired future conditions, a number of research studies were initiated in 1993, including an ecological classification of the area. Most of these were designed to describe and/or quantify existing ecosystem components; these characterizations would then serve as baselines to monitor and evaluate the effectiveness of management prescriptions to attain desired conditions.

Three prescriptions have been implemented thus far in the Wine Spring Creek project area. These are:

1. A large (500 acre) multiple purpose prescribed burn which focused on the restoration of declining pine-hardwood communities (April 1995);

2. A regeneration harvest study consisting of three replications each of shelterwood, 2-age, and group selection treatments in similar vegetative community types, carried out by commercial timber sale (September 1996 through November 1997);

3. Large woody debris augmentation in selected reaches of Wine Spring Creek and Bearpen Creek (September 1997).

Research is continuing on the results and effects of these manipulations. As of December 1998, there have been 47 publications and presentations, and 10 reports on research findings from the Wine Spring Creek project.

Plans are currently underway to develop a horse trail system in the area.

Management Activities

- Prescribed Burn
- Road Restoration
- Oak Regeneration
- Wildlife Opening Maintenance
- Large Woody Debris Addition
- Horse Trail Development
- Other Pre-existing Uses

Framework for developing an ecosystem management project

Land and resource management plan

Management Areas for Wine Spring Creek and associated management emphases and standards

Desired conditions for resources specified through planning sessions with potential partners

Existing data

Exploratory/Inventory Activities

Manipulations & monitoring

Wine Spring Creek program history

- "Bottom up" approach
  - Project first conceived in 1990 as a challenge cost share effort between Wayah RD and conservation organizations for wildlife and fisheries habitat improvement
  - With implementation of "New Perspectives" project evolved into demonstration of ecosystem management in 1991
  - Became part of Southern Appalachian CRP and then Southern Appalachian Ecosystem Research and Sustainability CCT with \$75 - \$150 yr^{-1} funding from WO in 1993-98
- Process for building desired resource conditions
  - Conditions derived from workshops over 18 month period
  - Participants comprised of Federal and university scientists, Federal & State land managers, environmental and conservation groups, public input through NEPA process
  - Consensus building identified 35 desired resource conditions
- Status
  - 40+ publications, 20+ presentations, 10+ reports
  - 30+ studies completed or in progress
  - Visited by universities, international groups, conservation groups
  - Part of the Managing Forest Ecosystems course hosted by Clemson University

Site-Specific Desired Future Conditions for Wine Spring Creek Project

Specific desired future conditions for the project area have been established by District staff and project participants. DFC's listed below address an ecosystem approach to management and incorporate management area direction.

Populations of native fish species in Wine Spring Creek and tributaries which equal or exceed current levels.

A range of large woody debris in project area perennial streams which approximates conditions occurring in late successional (greater than 100 years old) stages of vegetation, as indicated by current research (Hedman & others).

A continuous supply of large trees (greater than 20 inches DBH) of native species in riparian areas.

Increased productivity of selected stream reaches in terms of measured dissolved calcium concentration and/or biomass of algae, invertebrates, and fish.

Maintenance of a diversity of stream productivity levels as determined to be needed for maintaining diverse genetic pools for aquatic species.

Annual sedimentation rates which maintain or enhance existing baseline fish reproduction and productivity.

A minimum of 5% of the area in old forest reserve stands, representative of existing forest community types, and consisting of 100 acre blocks where possible.

A continuous corridor of old forest reserve stands across management area 4C, linked to old forest reserve stands outside the project area.

A continuous corridor consisting of old forest reserve stands, riparian areas, and/or trail corridors across management area 1B, linked to similar habitats outside the project area.

At least 50% of each compartment in hard mast producing acres, i.e., hardwood or hardwood-pine forest types containing oak and/or hickory which equal or exceed 40 years of age.

Enhanced soft mast production, especially where laurel and/or rhododendron coverage currently exceeds 50% of an area.

A continuous supply of early successional forest habitat (less than 10 years old) in a range of opening sizes from one half acre to 40 acres, but primarily less than 25 acres, on 5-10% of Management Area 1B.

A continuous supply of early successional forest habitat (less than 10 years old) in a range of opening sizes on 0.5-5% of Management Area 4C.

An average of one large den tree and/or snag (greater than 20 inches DBH) and 5 small snags (greater than 6 inches DBH) per two acres across the project area.

a

A minimum of 25 acres of evergreen cover (pine, rhododendron, laurel, etc.) per square mile of hardwoods in patches at least 3 acres in size in Management Area 1B.

Grass/forb openings on at least 3% of Management Area 1B and 0.5% of Management Area 4C, distributed across the area, with some located within riparian areas.

A distribution of at least one half acre of grass/forb brood range per 40 acres in Management Area 1B.

Encouraged native herbaceous vegetation in and adjacent to grass/forb openings.

A diversity of soft mast producers in and adjacent to grass/forb openings.

Adequate cover, consisting of evergreens and/or dense hardwood saplings and/or shrub/brush thickets distributed along the perimeter of grass/forb openings.

Maintained existing road closures.

Maintained existing wildlife openings on Goat Bald and Jarrett Bald.

A natural state of vegetation on Rocky Bald, as determined by carbon analysis of the existing soil profile.

Regeneration of naturally occurring species on all sites, especially native pine species on oak-pine heaths, to maintain existing diversity.

Long-term fiber production which is sustainable in terms of nutrient removal in Management Area 1B.

A sustained yield of at least 500 MBF of sawtimber every 10 years from Management Area 1B.

Sustainability of all resources which are collected as miscellaneous forest products.

Recreational opportunities consistent with the current Recreational Opportunity Spectrum (ROS) inventory of roaded natural, including possible development of horseback riding trails, fishing access trails, and/or bank fishing access to Nantahala Lake.

A watchable wildlife interpretive site along Forest Service Road 711.

Scenic vistas with interpretive information along Forest Service Road 711.

An interpretive site along State Road 1310 overlooking Nantahala Lake.

Scenic Byway designation for State Road 1310.

National Recreation Trail designation for the currently undesignated segment of the Bartram Trail (north of the mouth of Wine Spring Creek).

A developed trail head for the Bartram Trail junction with state road 1310.

A permanent easement into the isolated tract of Management Area 4B land along the north shore of Nantahala Lake for the Bartram Trail and to provide access for management activities.

WSC Major Research Themes

- Ecological classification
- Riparian zone management
- Aquatic productivity/water quality/habitat alteration
- Sustainable productivity (regeneration, biodiversity, and biogeochemical cycles)
- Human dimensions and economic assessments
- Mammal, bird, insect, and herpetofauna populations
- Special ecosystems ("Balds")
- Special products (ramps, moss, ginseng)
- Decision support system development

Project Site

The project area consists of the entire watershed on Wine Spring Creek (shown in aerial view), along with National lands in the watersheds of several smaller streams with a total land area of 4420 acres. Elevations range from 3000 ft at Nantahala Lake to 5440 ft at Wine Spring Bald. The project area encompasses 8 Management Areas in the Land and Resource Plan as specified below:

Management Areas	Management Emphasis	Size (ac)
1B	Sustainable timber supply and other traditional forest uses	1865
2A & 2C	Pleasant scenery for visitors and habitat of older forests for select animals	161
4A & 4C	Nonmotorized recreational use, mature forests for bear and animals requiring similar environments, pleasing scenery	2328
14	Protection of National Scenic Trail	60
17	Mountain bald maintenance	12
18	Riparian areas and associated plant and animal communities	Interspersed in other management areas

Past land use history of the study site is representative of the forested southern Appalachian Mountains. Native Americans and early settlers practiced frequent burning and grazed livestock in the forest. All the land was acquired from private ownership beginning in 1912 and most of the area was heavily logged prior to Forest Service acquisition. Since 1970, there have been three timber sales in the area totaling 3,700 MBF of sawtimber and 1,710 CCF of roundwood.

Community Types

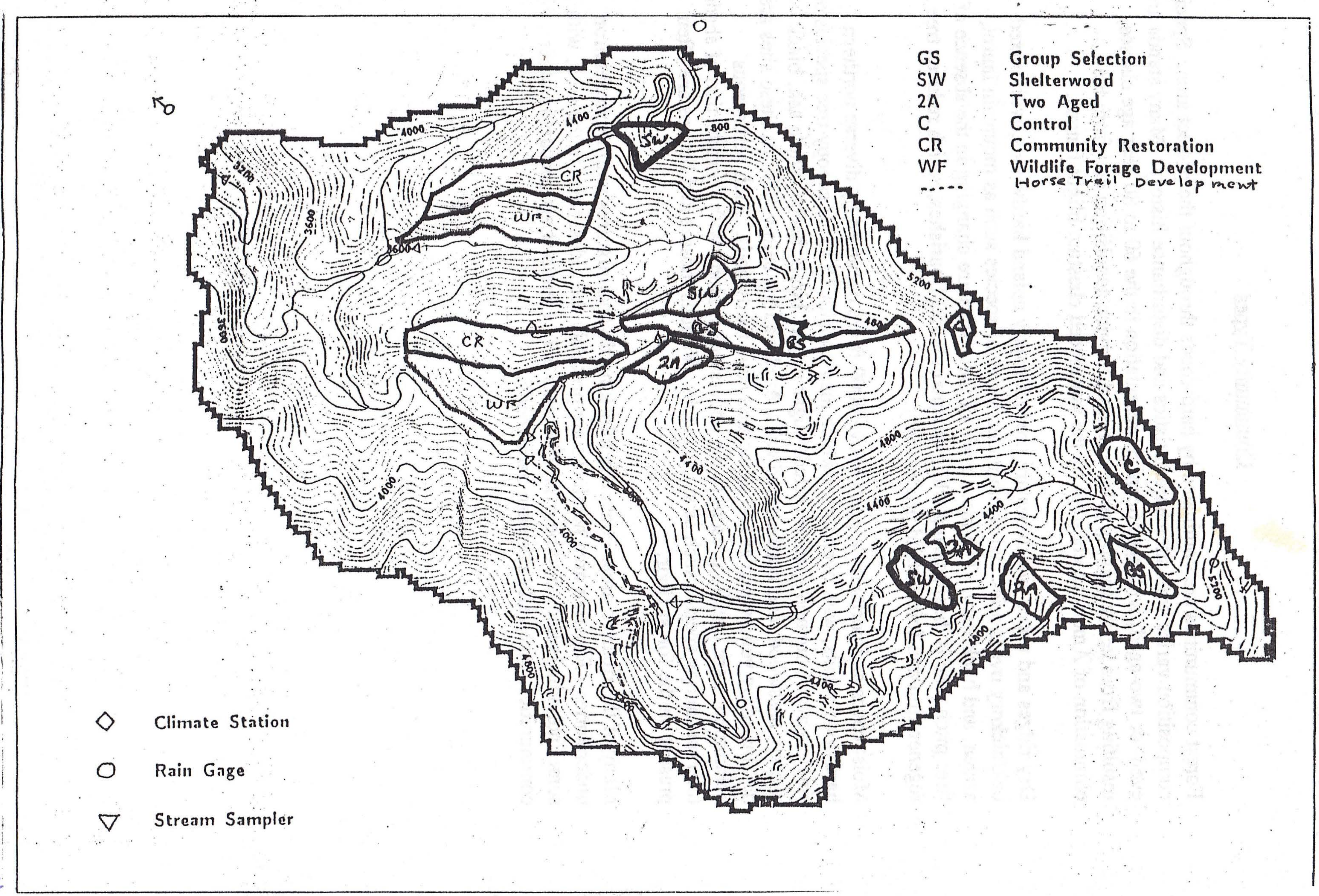
Forest communities are dominated by hardwoods throughout the project area. Species composition varies with site characteristics and disturbance history. Many stands are even- or two-aged, with significant representation in the 60 to 80 year age classes, resulting from heavy logging prior to Forest Service acquisition and from the elimination of American chestnut by the introduced chestnut blight fungus.

Dry ridges and upper sideslopes are predominantly upland hardwoods, with mixed oak/hickory overstories and shrub understories of species such as mountain laurel, azalea, and buckberry. The more xeric of these sites are changing in the absence of fire: pitch pine is disappearing while mountain laurel flourishes, which reduces tree regeneration and forest stand productivity.

Moist coves and northerly aspects above 4000 ft are occupied by diverse northern hardwood stands, with overstories which may contain 15 to 20 canopy tree species on a single acre. Common species include sugar maple, birch, beech, white ash, black cherry, basswood, and northern red oak. At elevations below 4000 ft, these sites are dominated by yellow poplar and associated cove hardwoods. Rich herbaceous communities are usually present in the understories, along with reproduction of shade tolerant canopy species such as sugar maple. Various mosses and lichens are often present on the forest floor.

Many of the riparian areas contain hemlock-hardwood mixtures with rhododendron understories. Riparian area hemlocks are probably the oldest trees in the area, with some individuals known to be over 300 years old. Hemlock also occurs in other communities, especially northern hardwoods.

Proposed Ecosystem Management Alternatives
Wine Springs Watershed



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WINE SPRING CREEK
ECOSYSTEM MANAGEMENT PROJECT

PROPOSED ACTIVITIES
FOR 1995 GROWING SEASON

R_x BURN for restoration of pine-hdwd community type ( )

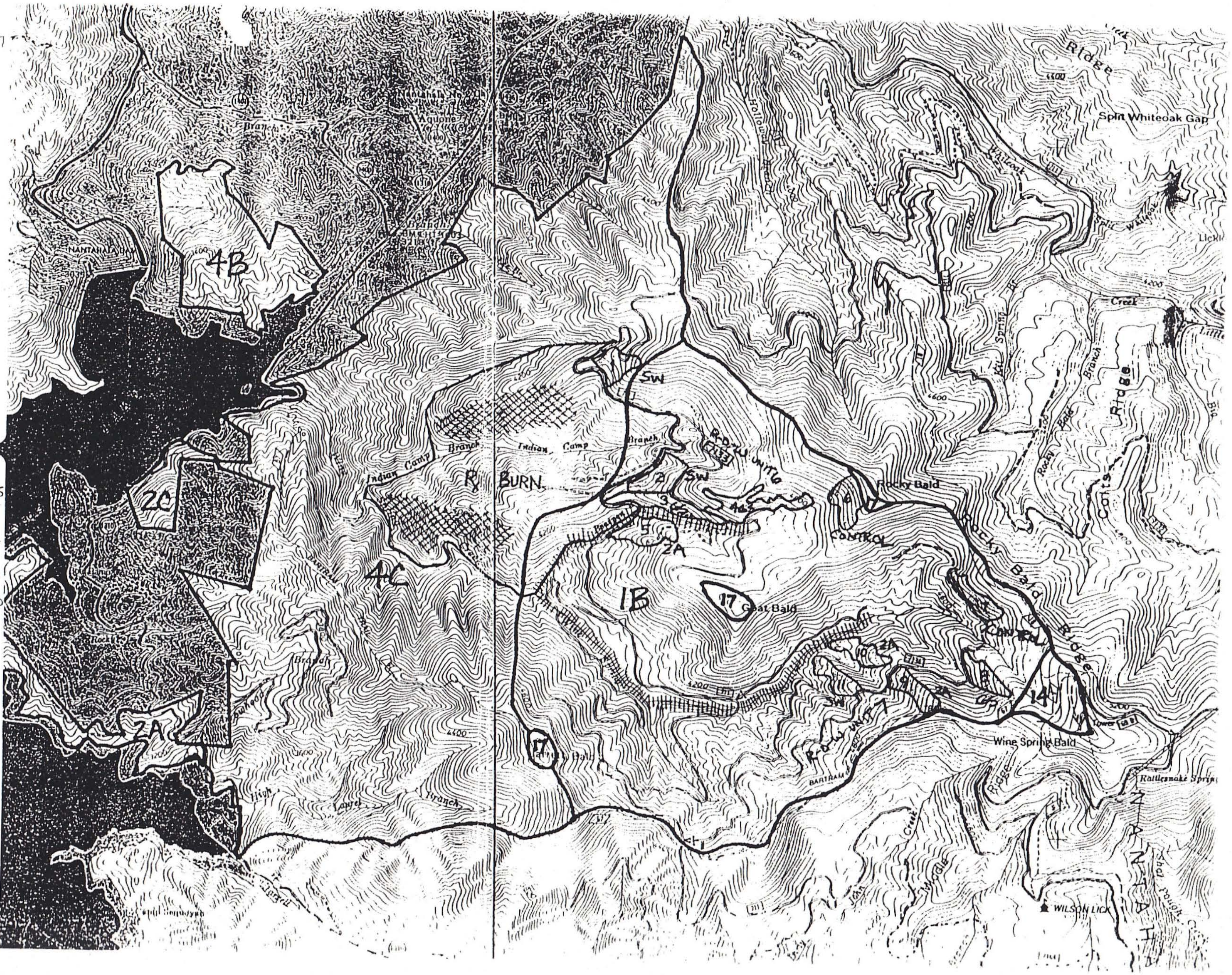
WOODY Debris augmentation ( )

Regeneration Harvest areas (5) - see below

PROPOSED
REGENERATION HARVEST AREAS

AREA		GPS ACRES	PROPOSED TREATMENT
1	[illegible]	10.8	SHELTERWOOD
2	80 30	15.9	SHELTERWOOD
3	82 29	33.2	GROUP SELECTION
4	82 35		
5	82 34	16.6	* 2-AGE
6	82 36	16.9	CONTROL
7	82 58	12.0	CONTROL
8	[illegible]	11.1	GROUP SELECTION
9	[illegible]	14.0	* 2-AGE
10	[illegible]	9.6	* 2-AGE
11	[illegible]	14.2	* SHELTERWOOD

* = tentative



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Water Quality Findings

- Water Temperature
- Streamflow
- Total Suspended Solids
- Source of Sediment in Bearpen Ck
- Effect of Burn
- Effect of Road Reconstruction
- Effect of Logging

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Water Quality Findings

- Watershed Scale, GIS-Based Model
  - » Tool for decison makers
  - » Simulation of sediment source
  - » Overland routing and deposition
  - » Delivery to drainage
  - » Instream deposition and transport

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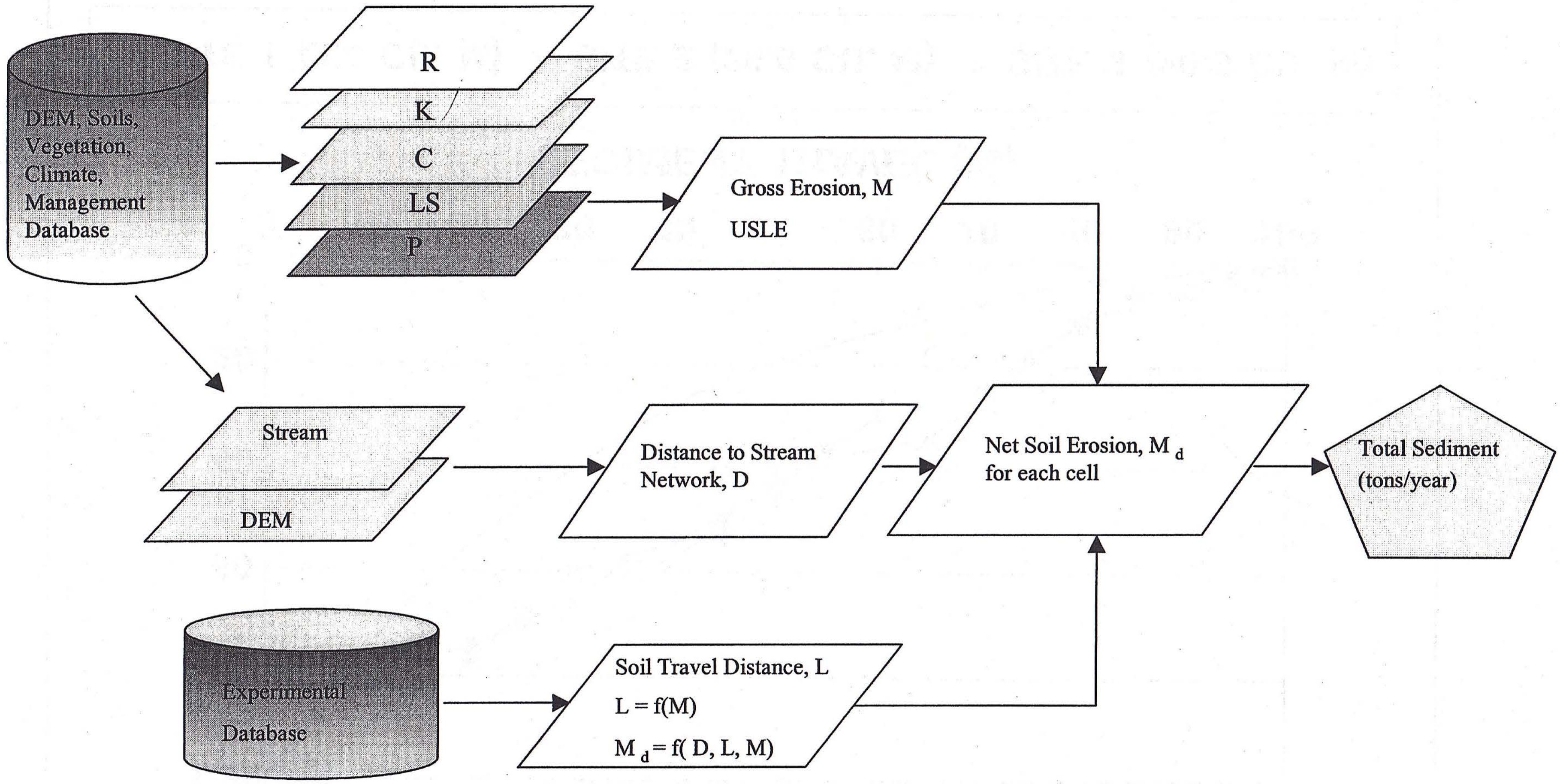

DEM, Soils, Vegetation, Climate, Management Database
R
K
C
LS
P
Gross Erosion, M
USLE
Stream
DEM
Distance to Stream Network, D
Net Soil Erosion, M_d for each cell
Total Sediment (tons/year)
Experimental Database
Soil Travel Distance, L
L = f(M)
M_d = f(D, L, M)

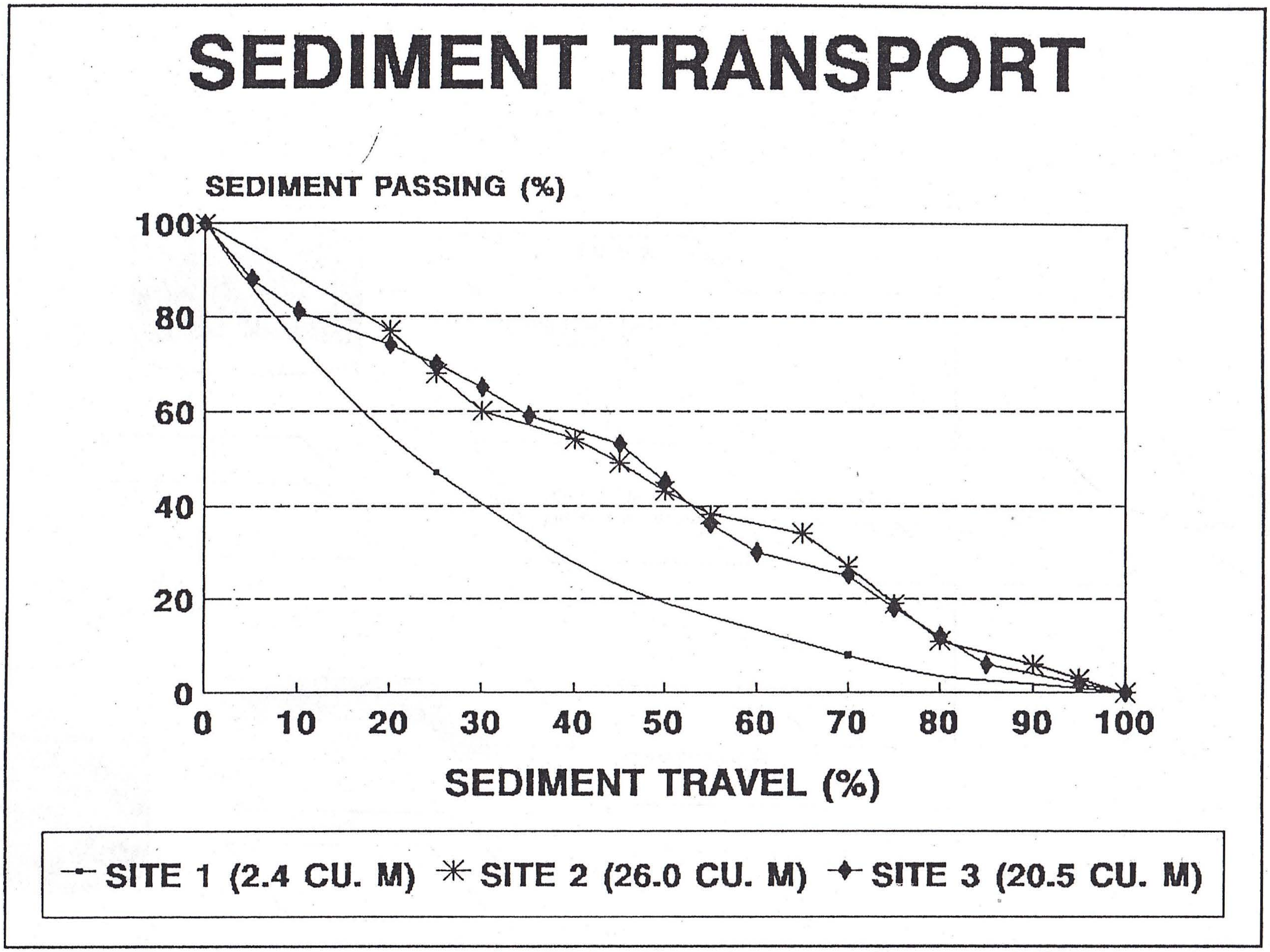
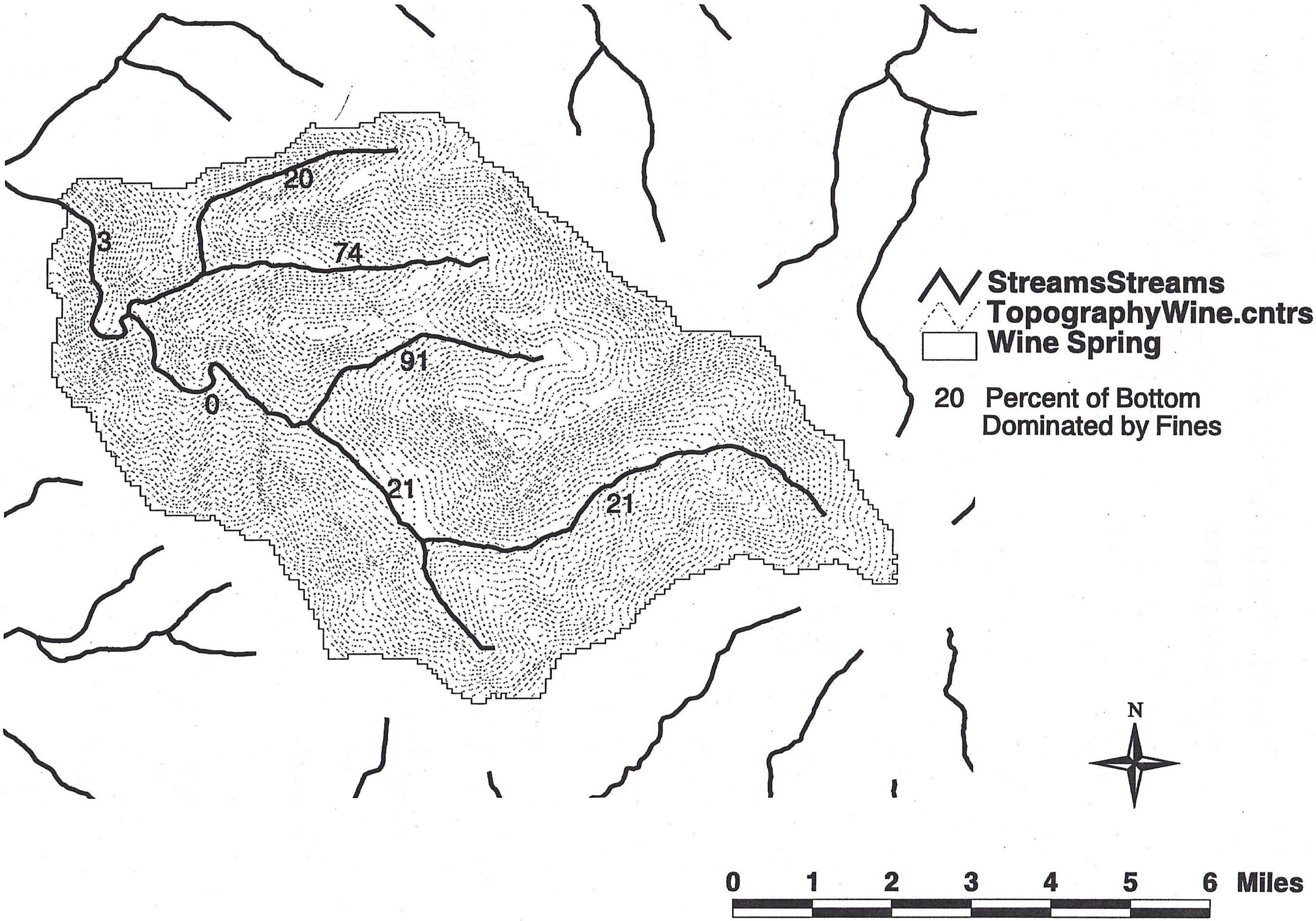


Figure 3 Percent of sediment volume deposited v. percent of total sediment travel distance, measured on three varying size sediment trails located near the Wine Spring Ecosystem Management Area.

Sediment Deposited In Streams



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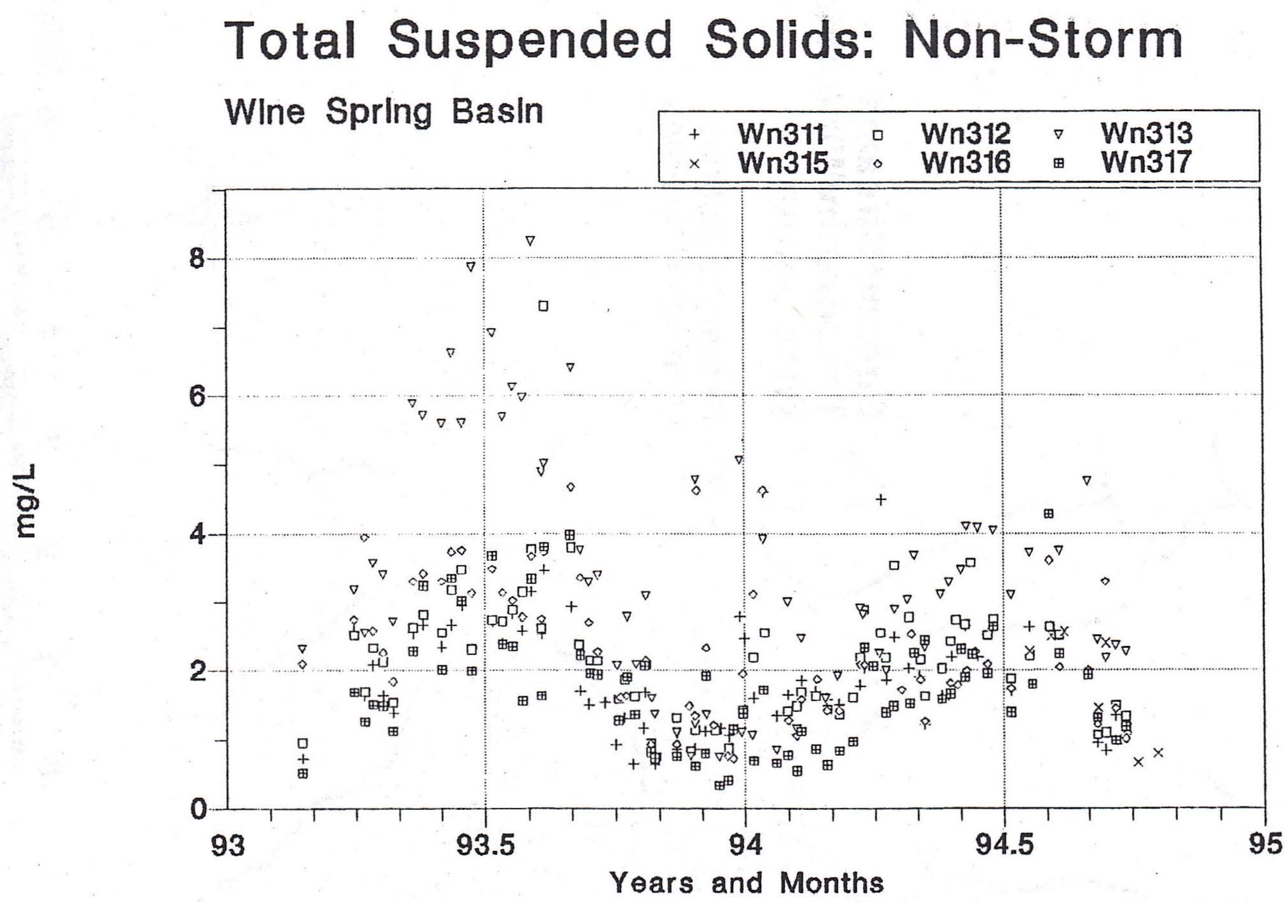
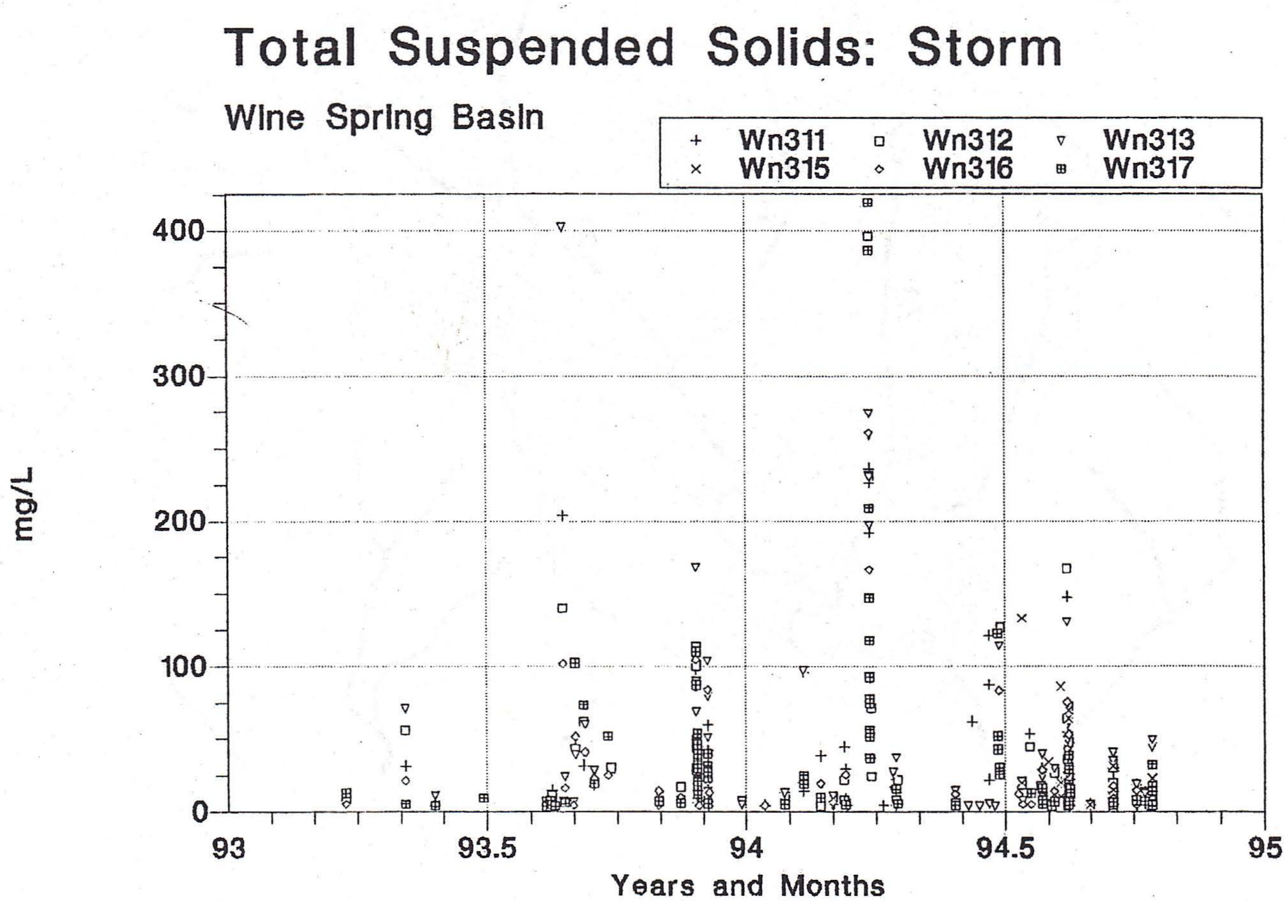
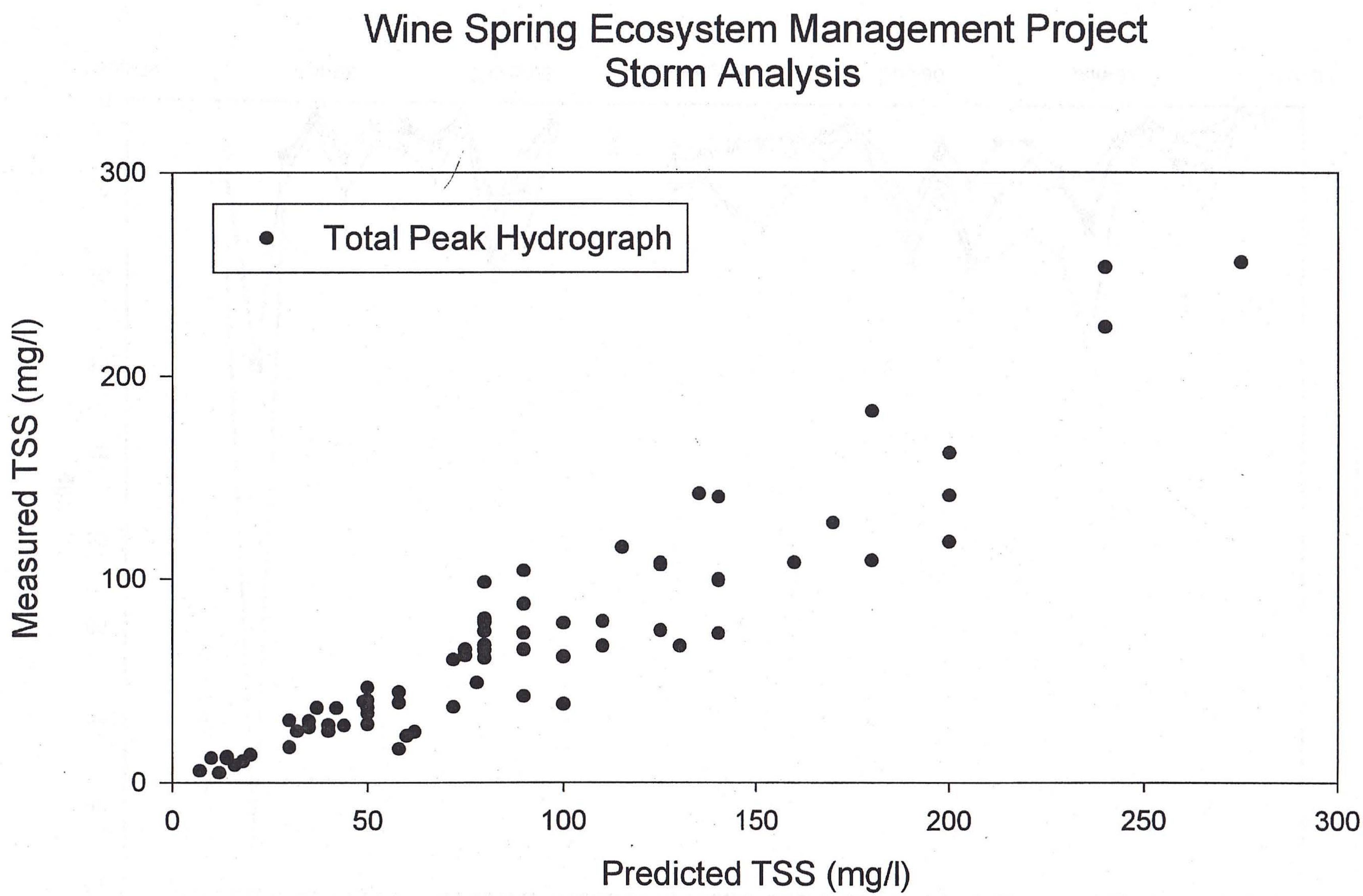
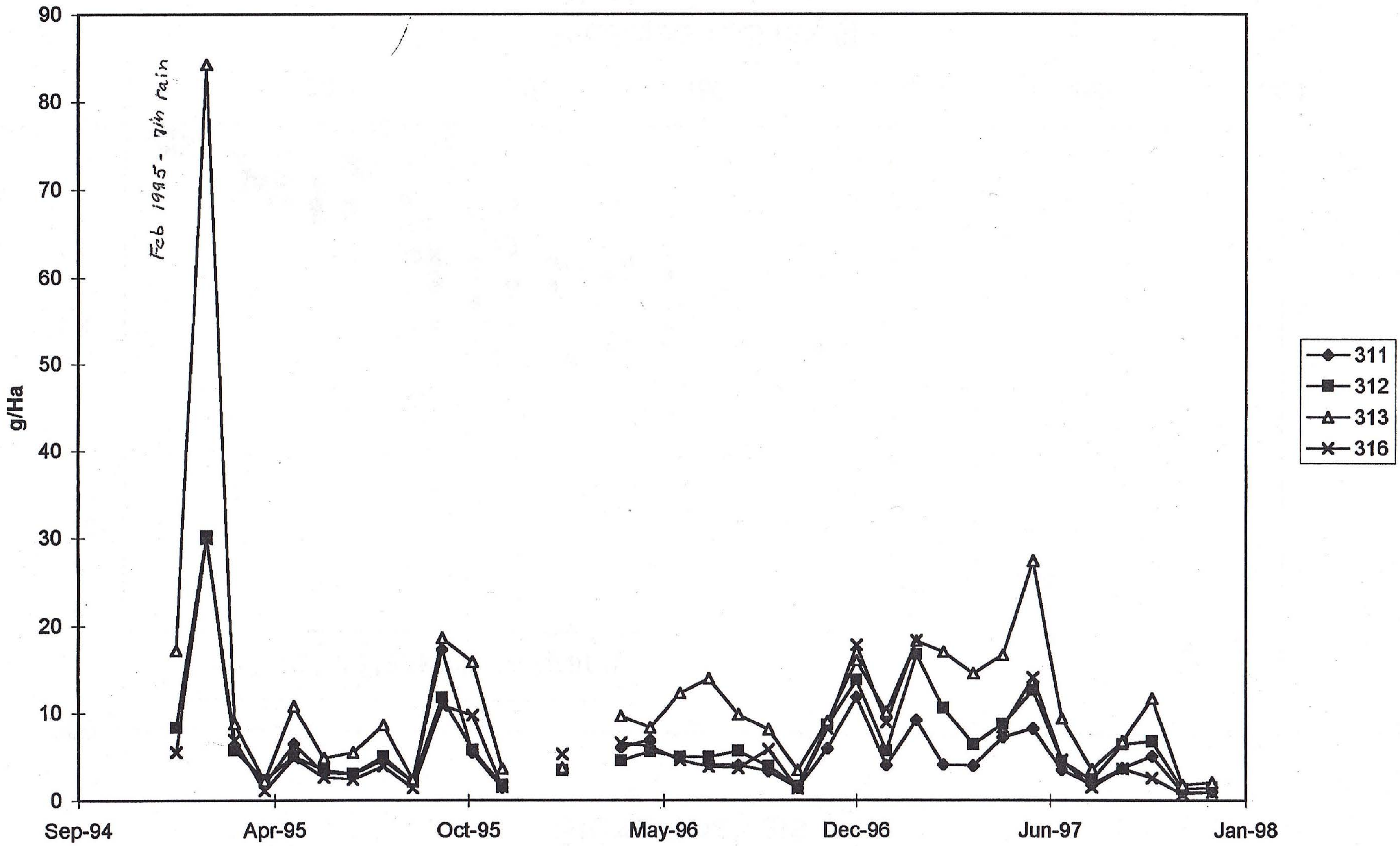

Total Suspended Solids: Non-Storm
Wine Spring Basin
Wn311
Wn312
Wn313
Wn315
Wn316
Wn317
mg/L
0
2
4
6
8
93
93.5
94
94.5
95
Years and Months


Total Suspended Solids: Storm
Wine Spring Basin
Wn311
Wn312
Wn313
Wn315
Wn316
Wn317
mg/L
0
100
200
300
400
93
93.5
94
94.5
95
Years and Months


Wine Spring Ecosystem Management Project
Storm Analysis
Total Peak Hydrograph
Measured TSS (mg/l)
Predicted TSS (mg/l)
0
100
200
300
0
50
100
150
200
250
300

22

Estimated Loading



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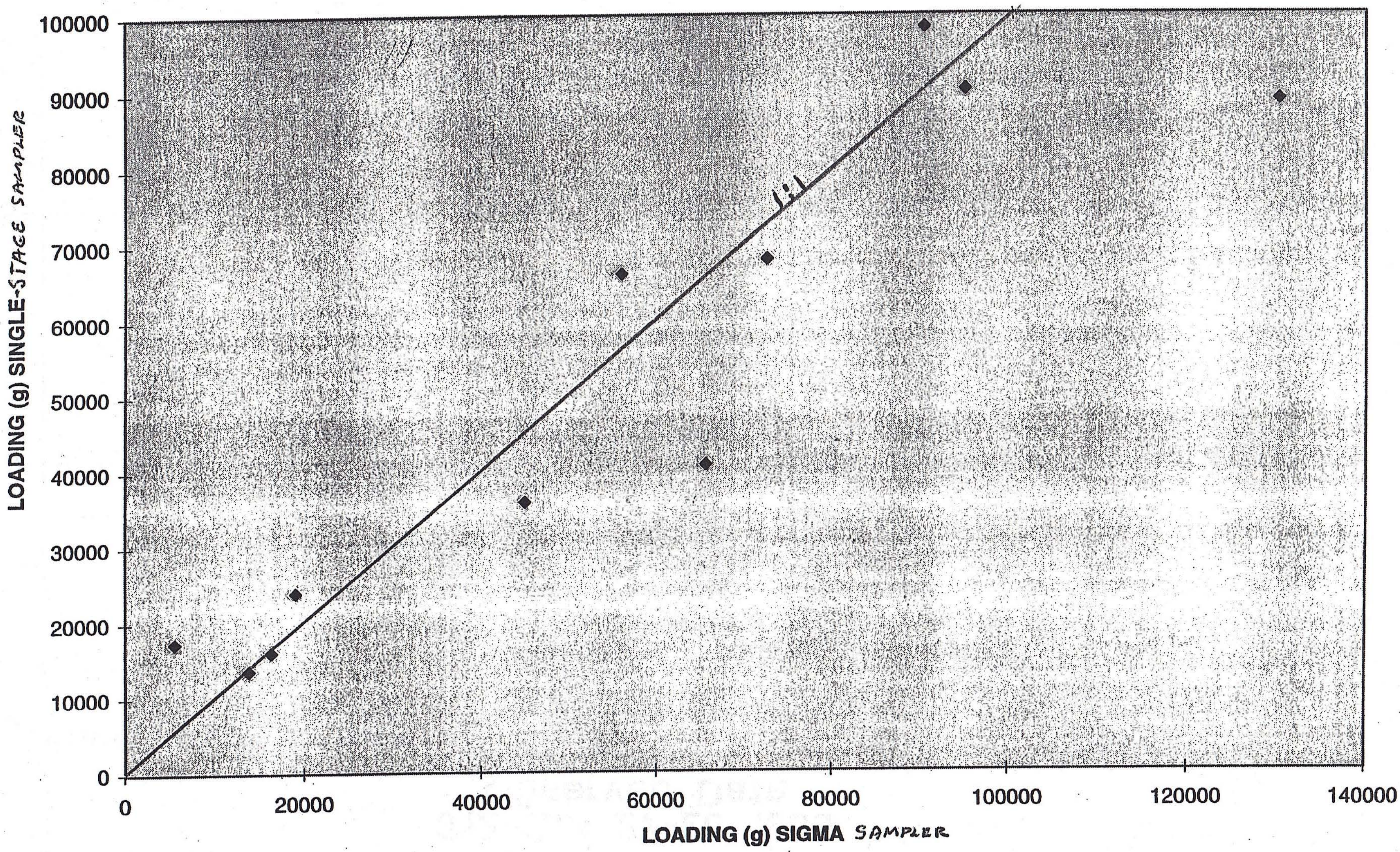
WINE SPRING 312



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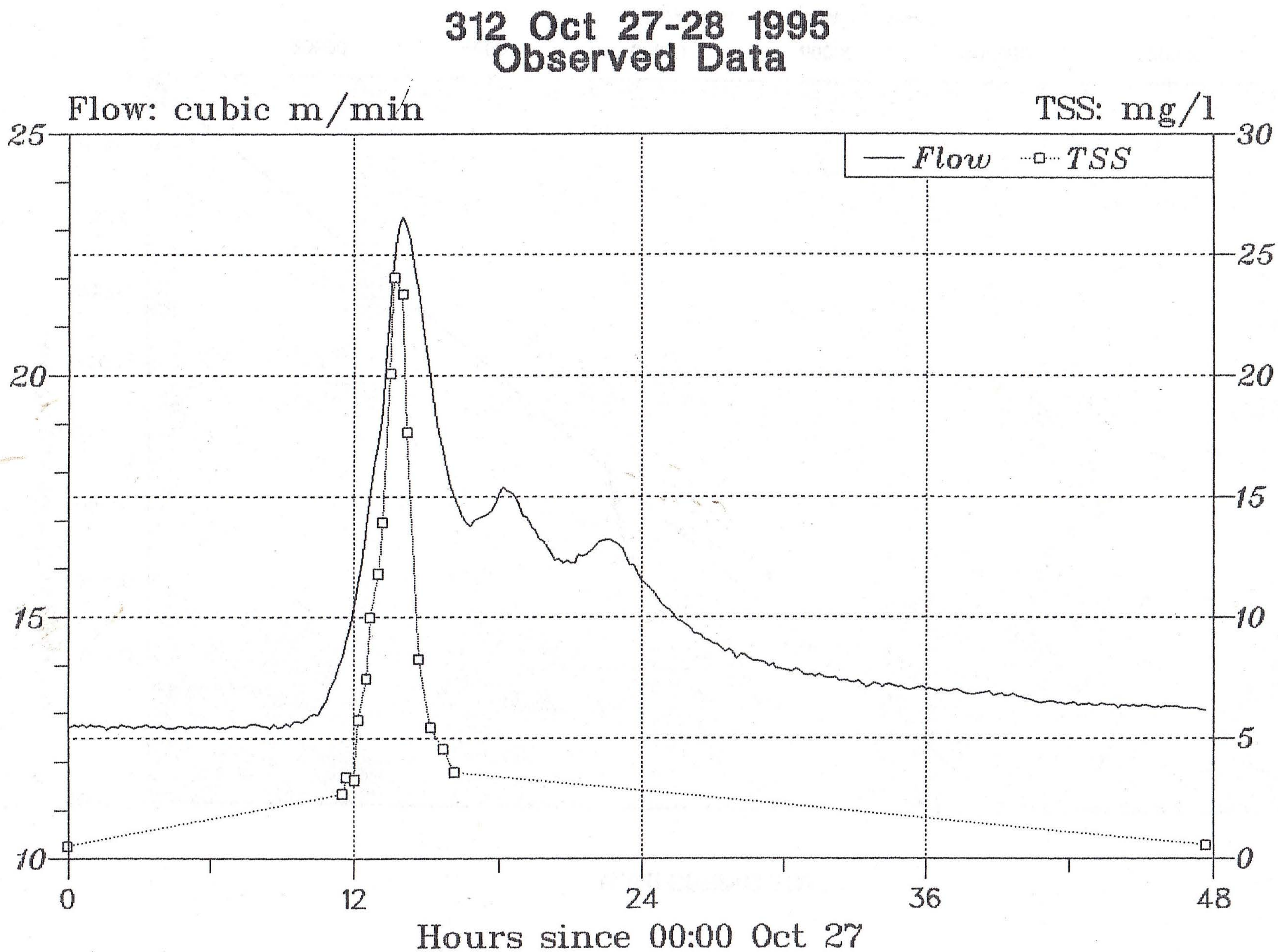
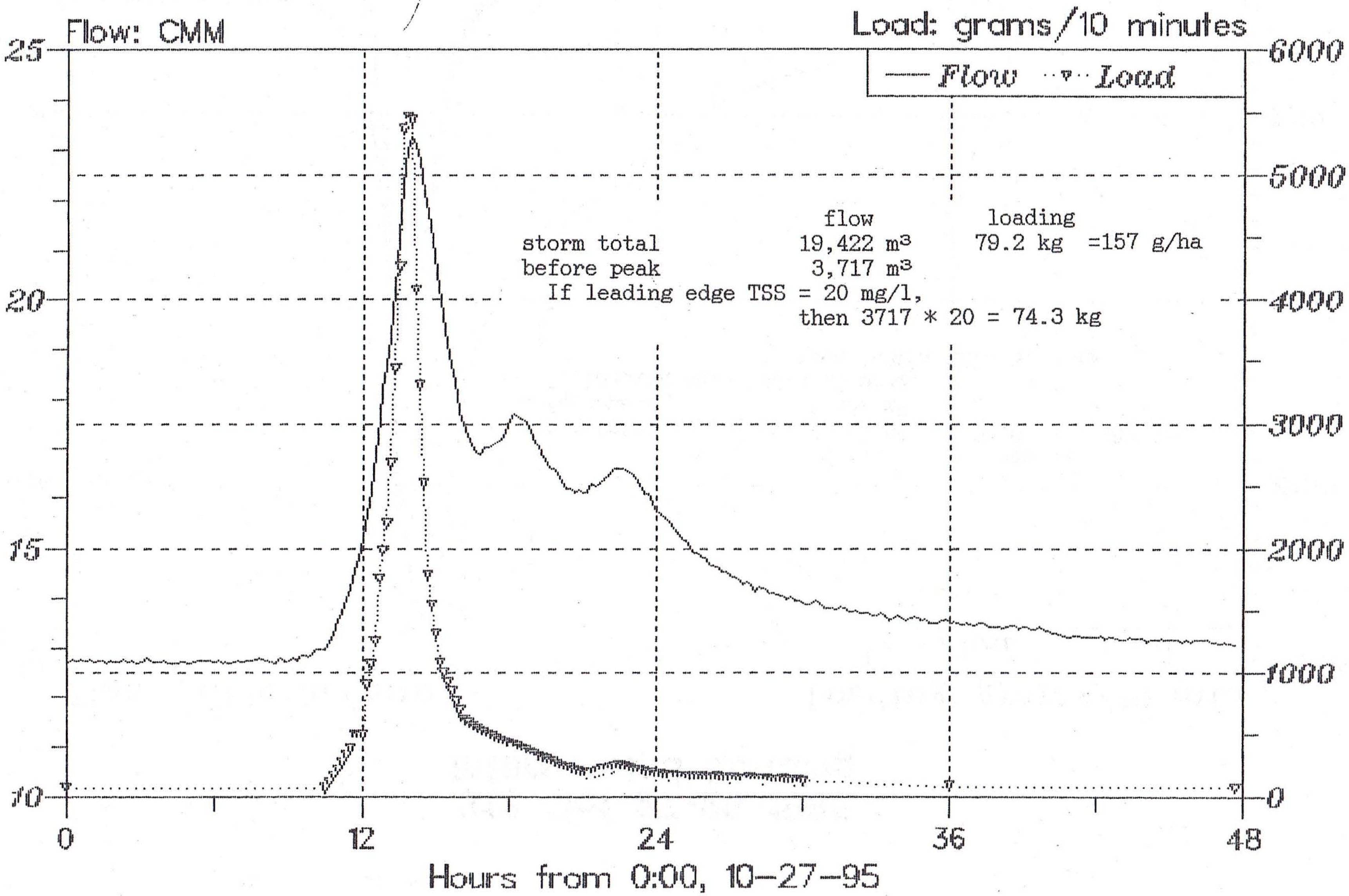
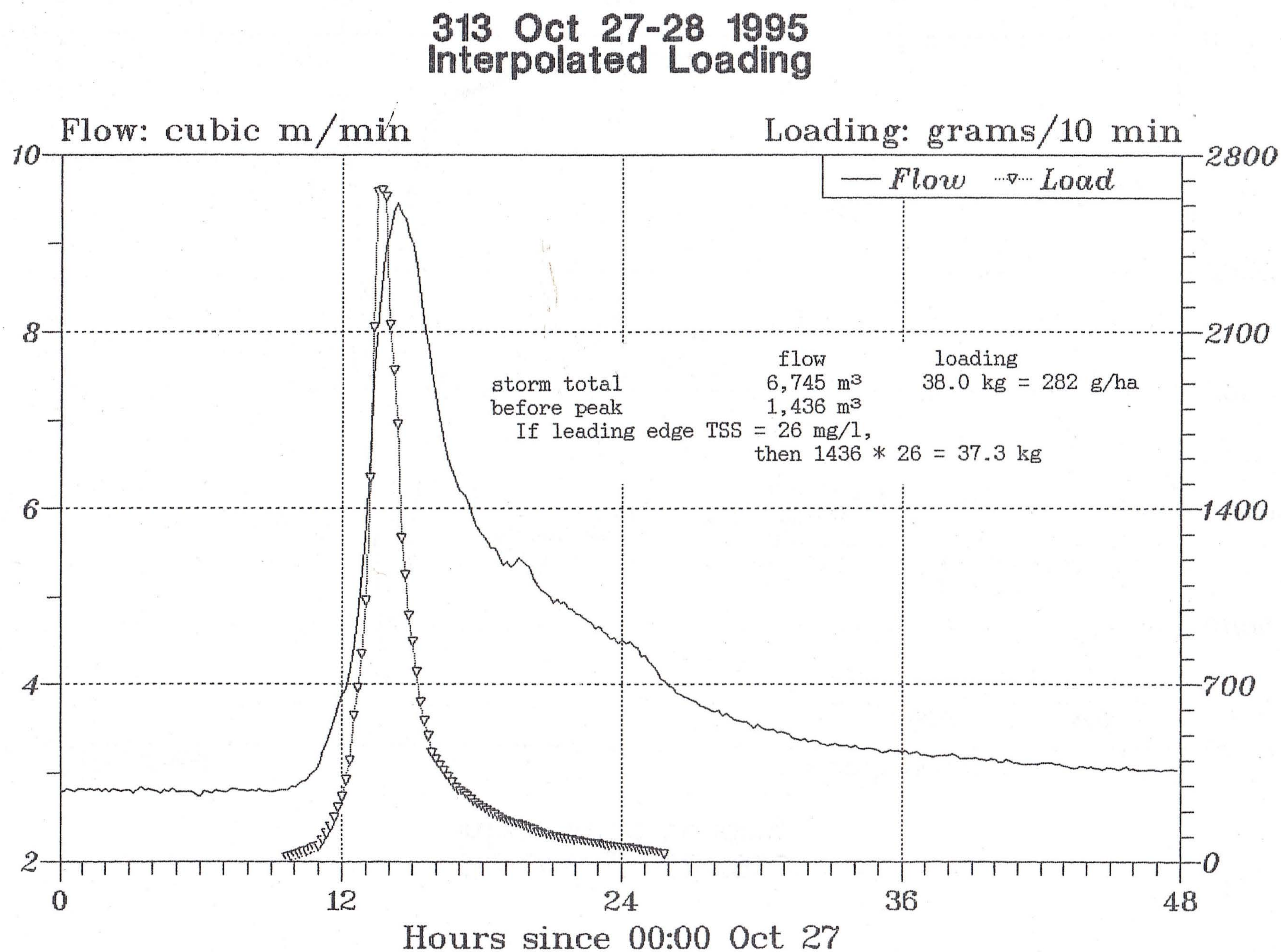

312 Oct 27-28 1995
Observed Data
Flow: cubic m/min
TSS: mg/l
Flow
TSS
25
20
15
10
30
25
20
15
10
5
0
0
12
24
36
48
Hours since 00:00 Oct 27

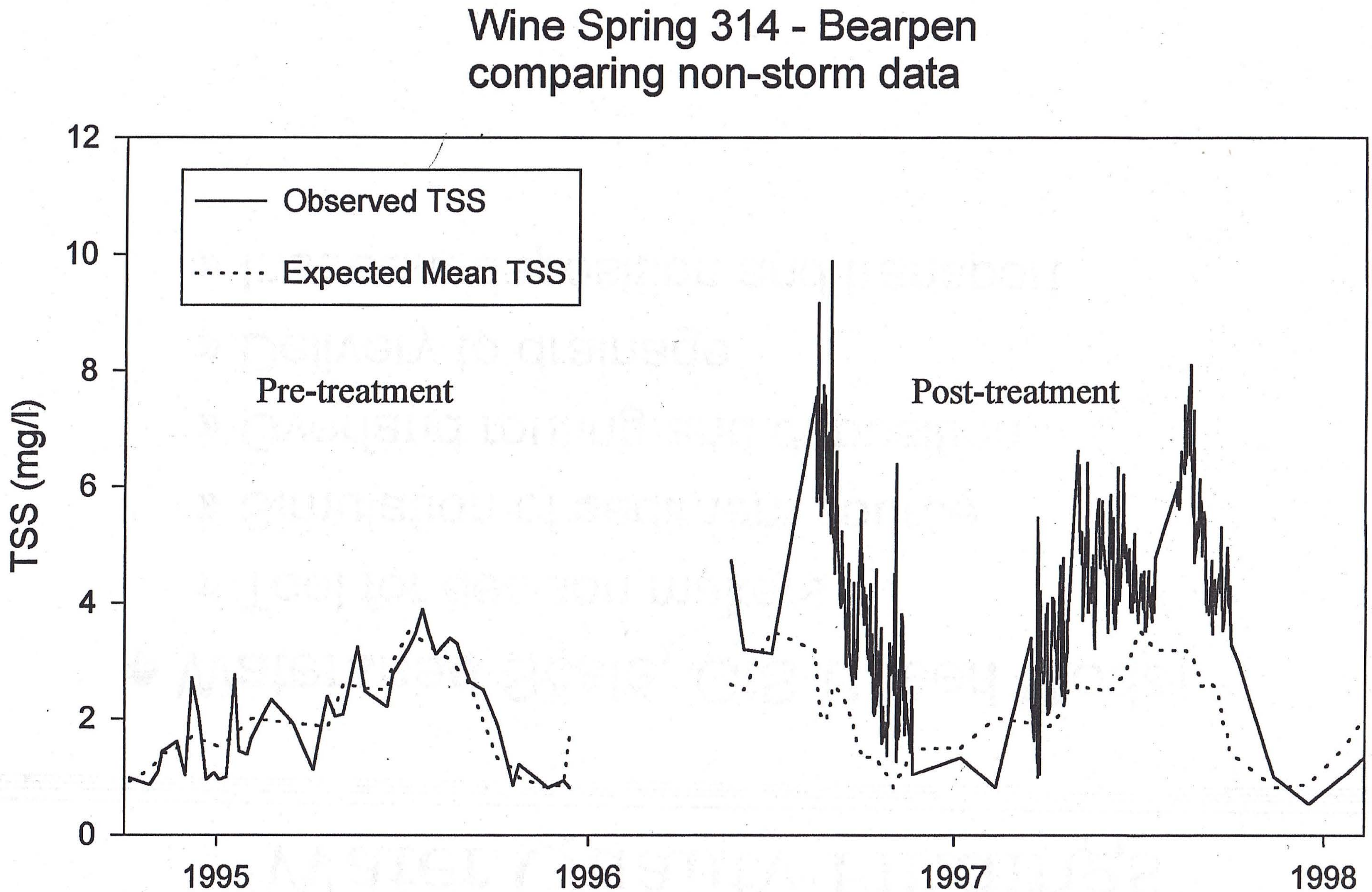
25

312 Oct 27–28 1995
Interpolated Loading




313 Oct 27-28 1995
Interpolated Loading
Flow: cubic m/min
Loading: grams/10 min
Flow
Load
10
8
6
4
2
2800
2100
1400
700
0
flow
loading
storm total
6,745 m³
38.0 kg = 282 g/ha
before peak
1,436 m³
If leading edge TSS = 26 mg/l,
then 1436 * 26 = 37.3 kg
0
12
24
36
48
Hours since 00:00 Oct 27

27



Wine Spring 314 - Bearpen
comparing non-storm data
Observed TSS
Expected Mean TSS
Pre-treatment
Post-treatment
TSS (mg/l)
0
2
4
6
8
10
12
1995
1996
1997
1998

28

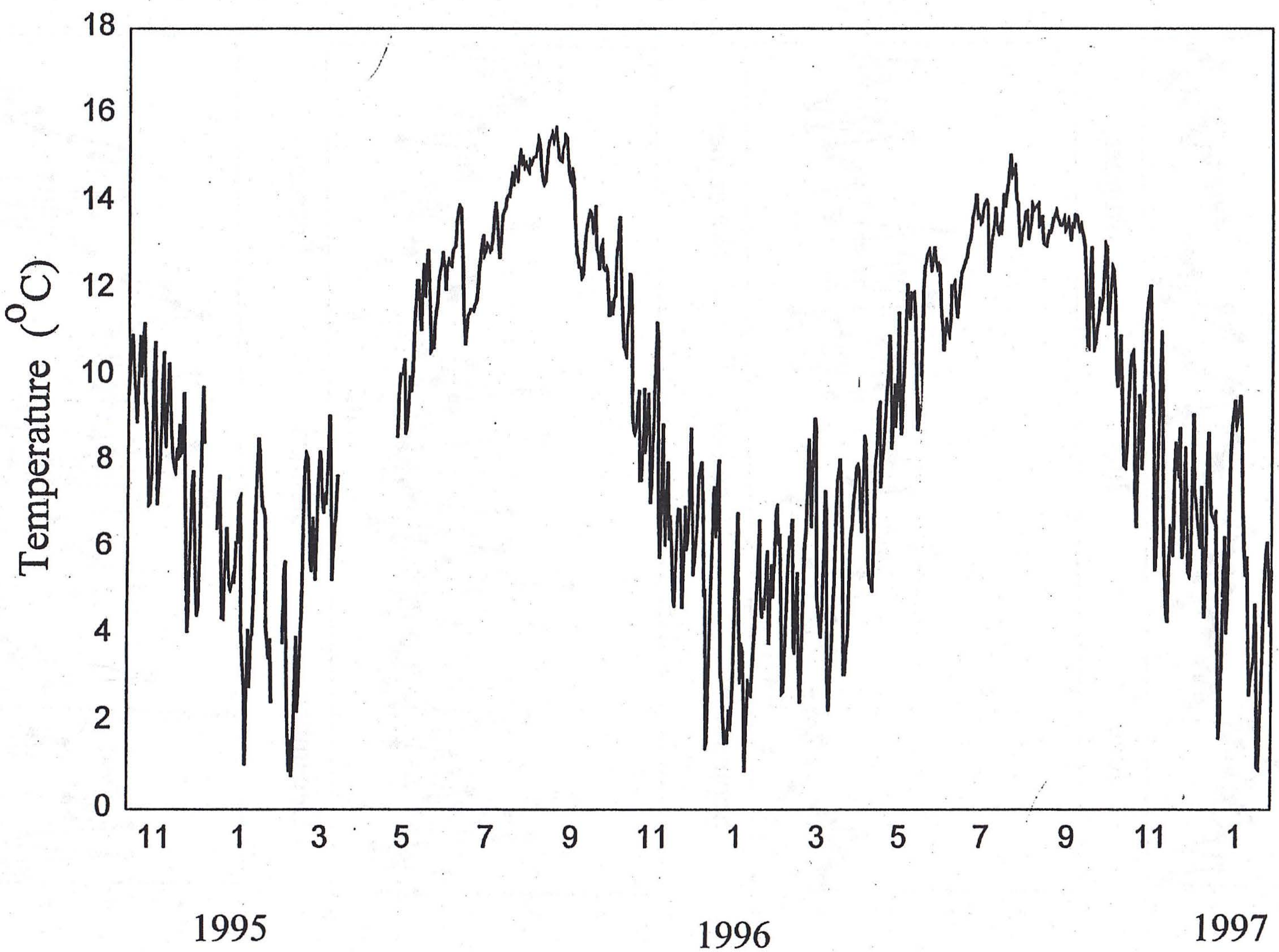


Fig. 2. Daily mean water temperature recorded at Site 312 at mid Wine Spring Creek.

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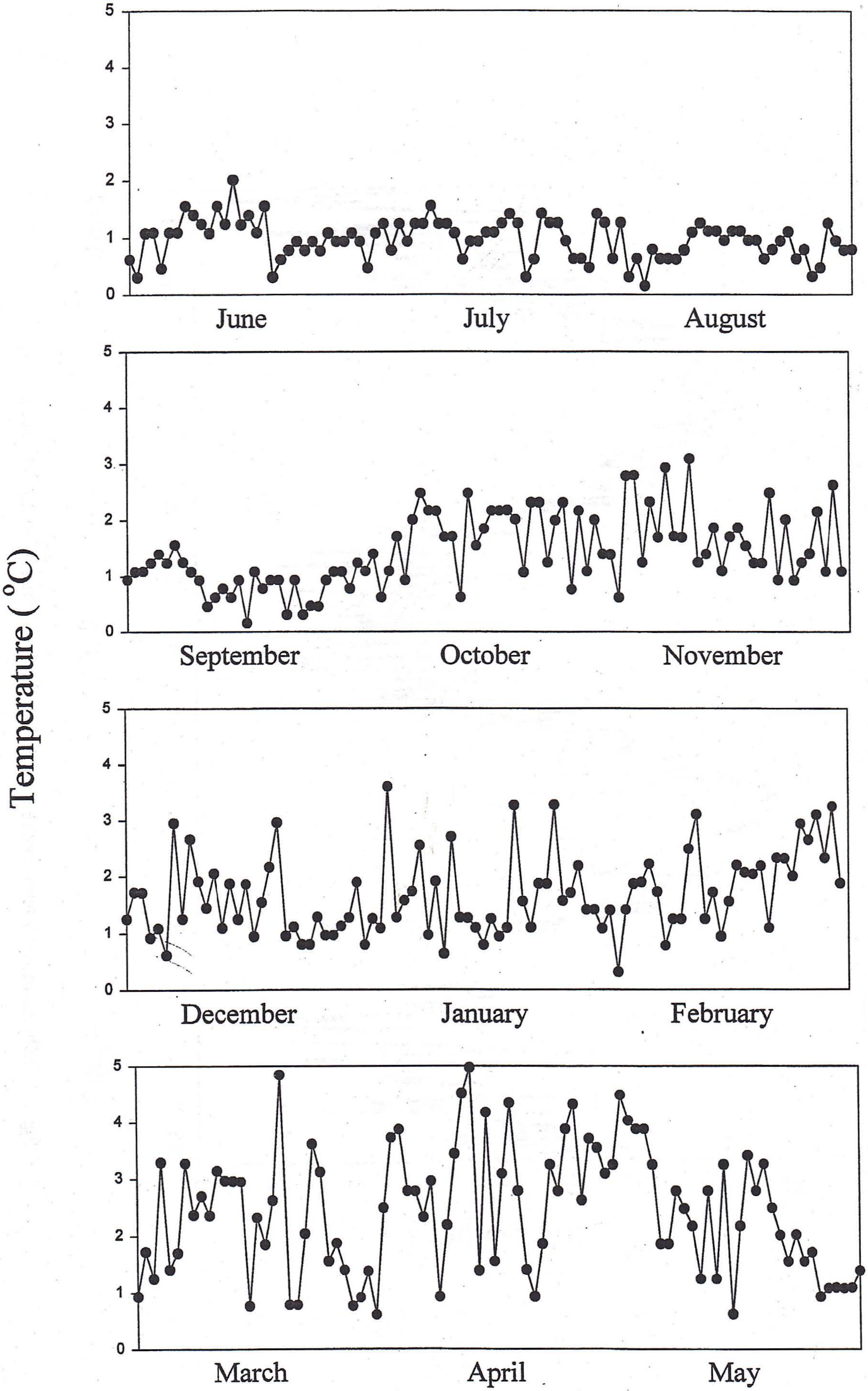
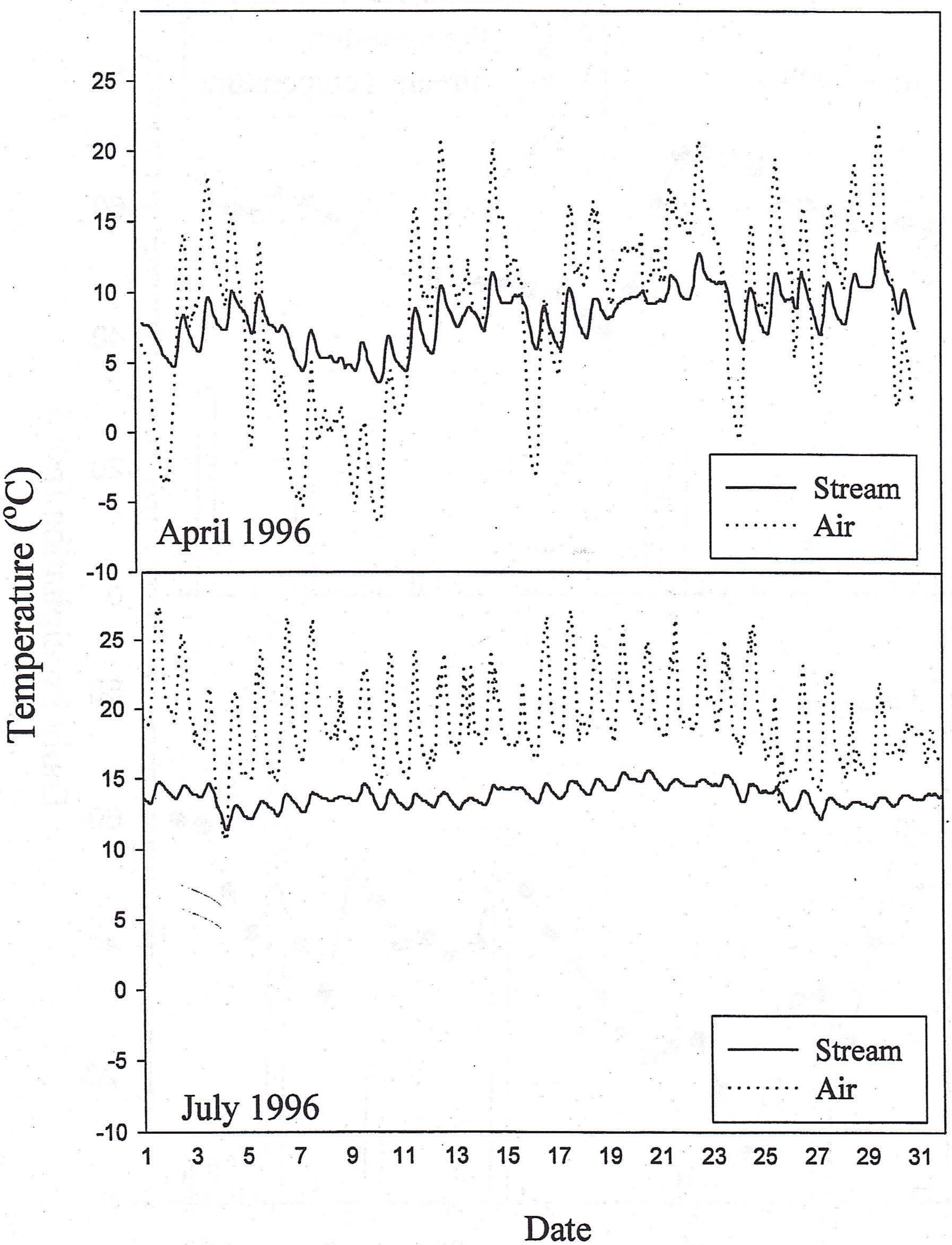
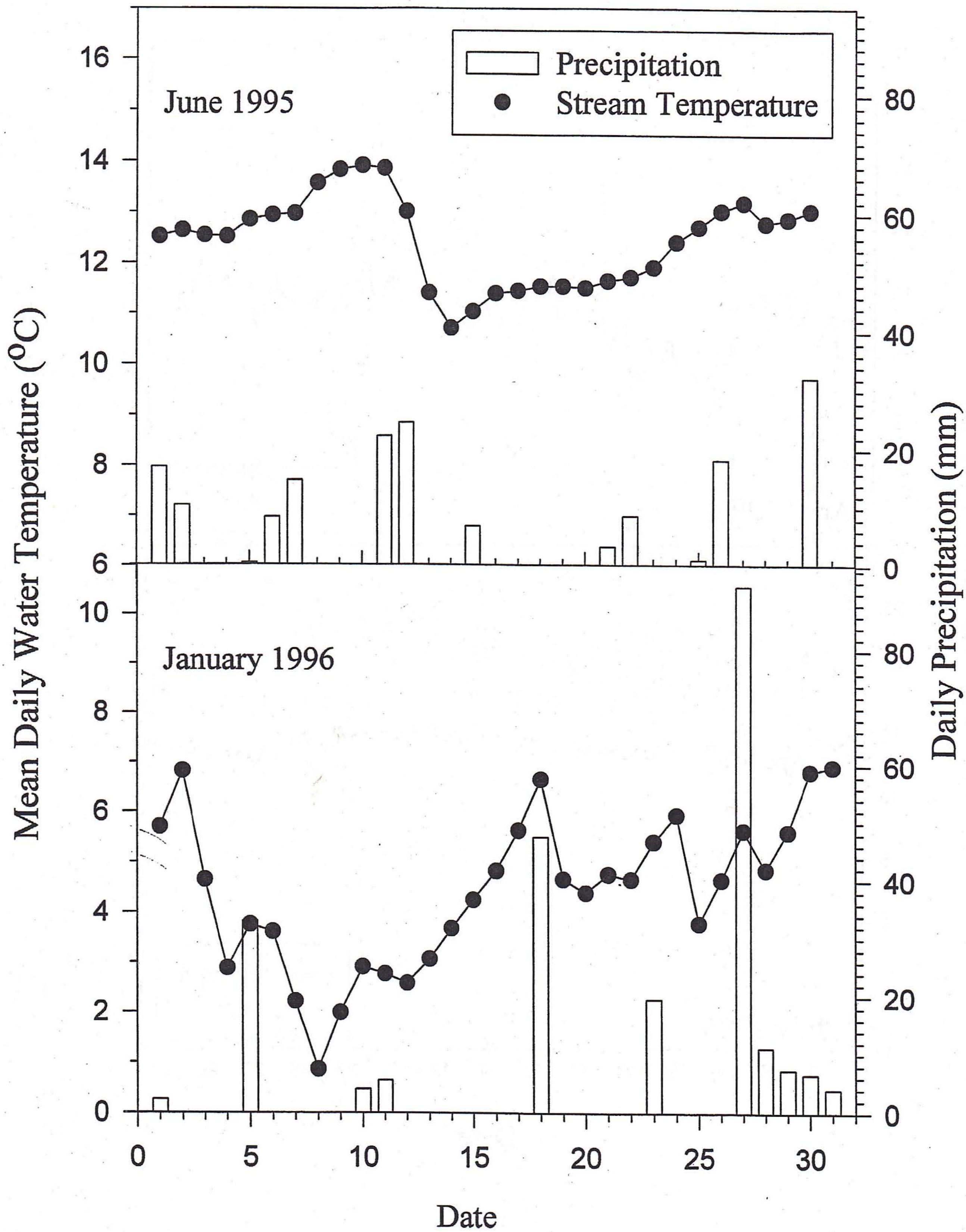
Wine Spring Creek (312)
Daily Range of Water Temperature



Wine Spring (312)



Wine Spring Creek (312)
Effect of Precipitation on Water Temperature



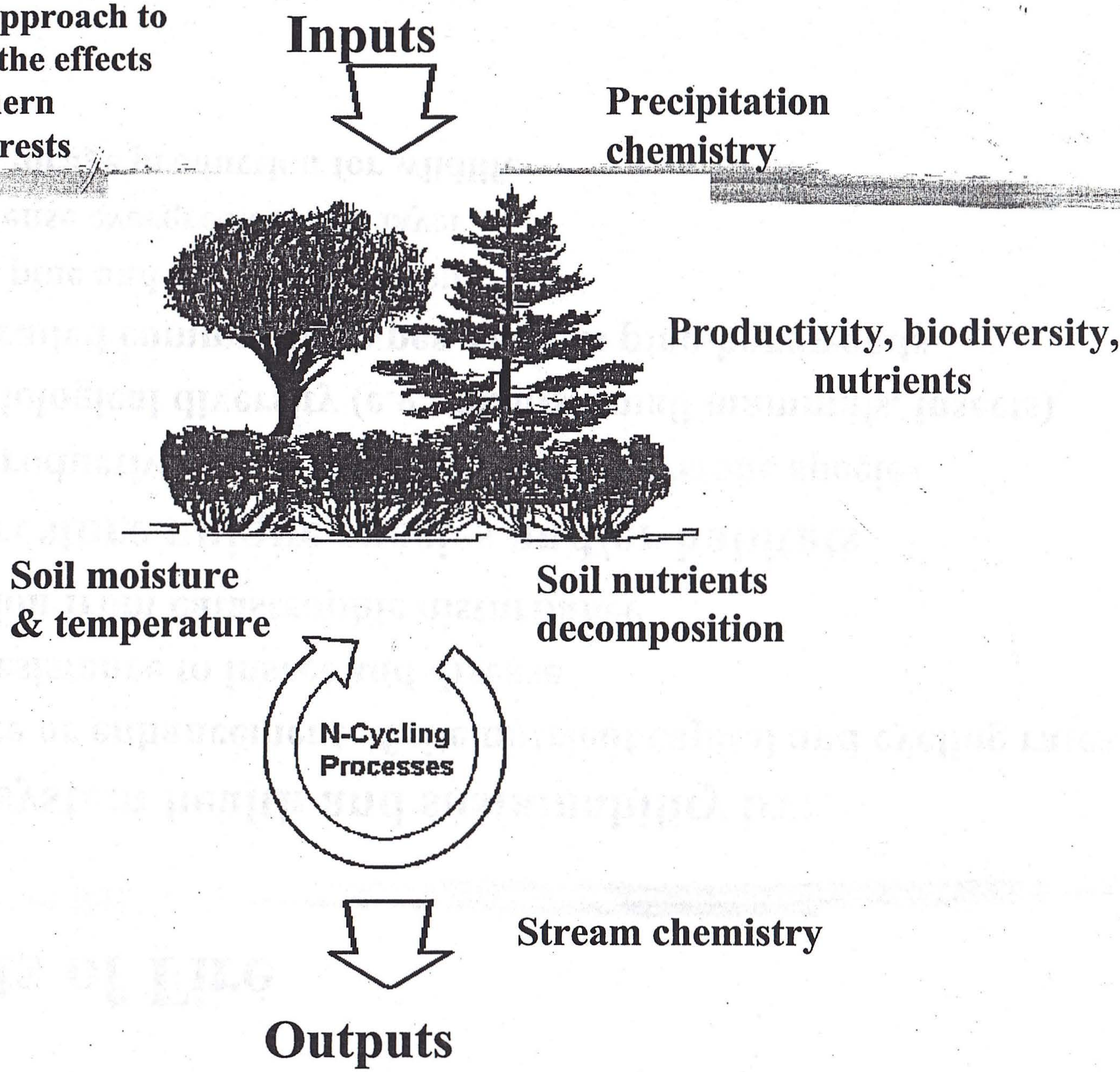
<u>Restoration of Degraded Forest Communities</u>

Prescribed fire is used as a silvicultural treatment in xeric, mixed pine-hardwood ecosystems of the southern Appalachians. Communities receiving this treatment typically consist of mixtures of pitch pine, scarlet oak, chestnut oak, red maple, and a dense understory of mountain laurel. While the pine-hardwood community is limited in extent, it is a unique vegetation type that provides important habitat for both flora and fauna. The combined effects of abusive land practices such as high grade logging and grazing, fire exclusion, and drought-induced insect (southern pine beetle) infestations have left these communities with sparse, low-diversity, and slow-growing overstories.

Pre-colonial wildfires are thought to have played a major role in maintaining a pine component in pine-hardwood communities by providing mineral soil for seed germination and reducing mountain laurel density and vigor in the understory. More recent fire exclusion, combined with drought related southern pine beetle infestations, has resulted in significant reductions in overstory pine and increased mountain laurel in the understory. These poor conditions have prompted the use of prescribed fire to restore these degraded ecosystems. The purpose of the prescribed fire is to reduce mountain laurel so that a productive and diverse pine-hardwood overstory can regenerate.

In the Wine Spring Creek watershed, a wide scale fire was prescribed in late April of 1995, before leaf out, to mimic a natural wildfire. This prescription created a mosaic of fire intensities. The fire killed many of the mountain laurel stems allowing new vegetation to develop. Vegetation development including pitch pine and oak regeneration is being monitored on this burned area.

An ecosystem approach to understanding the effects of fire on Southern Appalachian forests



Benefits of Fire

- **Increase ecosystem health and sustainability by:**
  - **maintenance or enhancement of site nutrient capital and cycling rates**
  - **increased resistance to insect and disease**
  - **risk reduction from catastrophic disturbance**
- **Preserve or restore unique species and/or habitats**
  - **enhanced productivity and regeneration of keystone species**
  - **enhanced biological diversity (e.g., plants, small mammals, insects)**
  - **restore degraded community types, such as pine-hardwoods**
    - **promote pine and oak regeneration**
    - **reduce dense evergreen shrub layer**
    - **promote forage production for wildlife**

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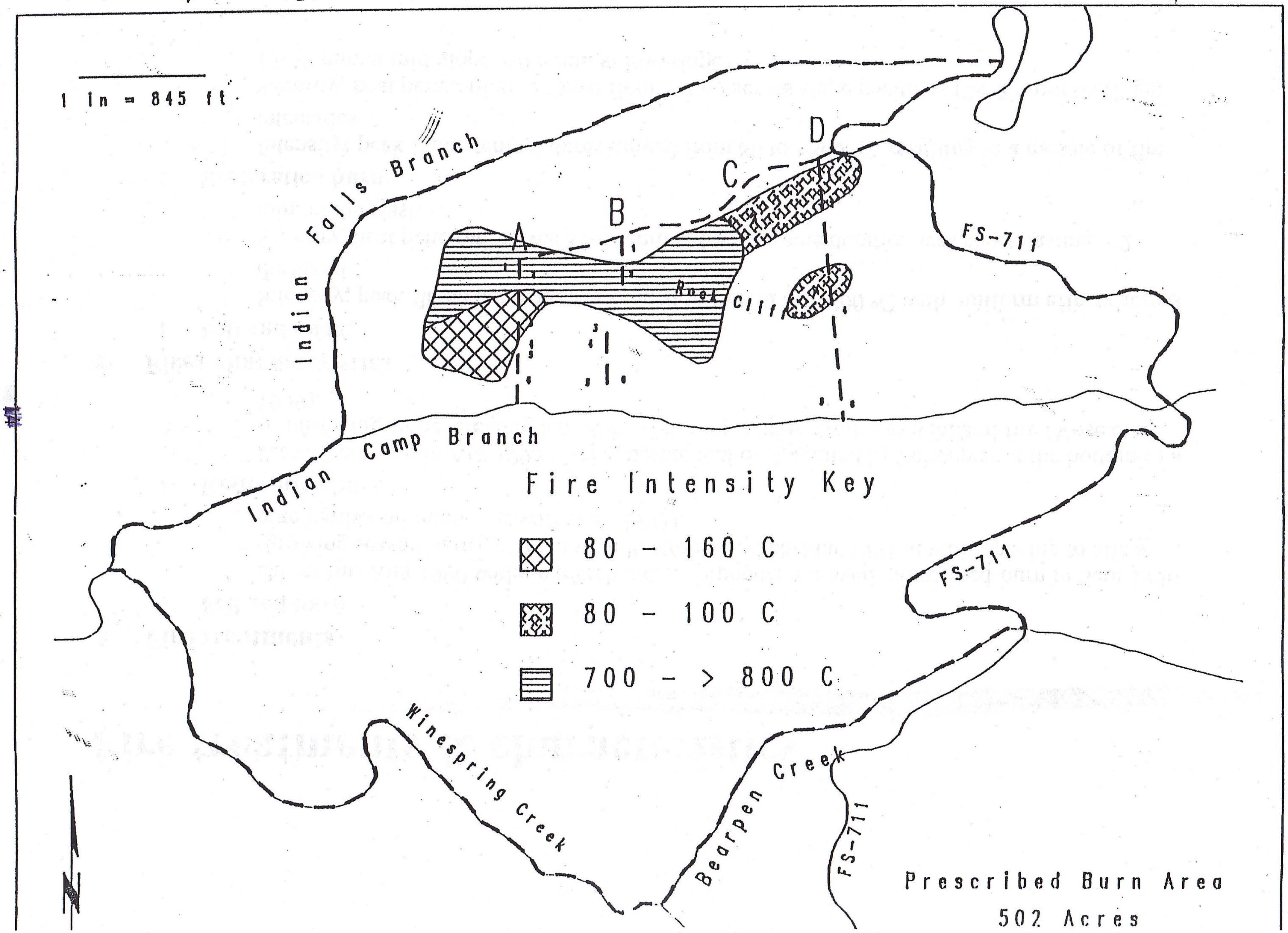
Wine Spring Creek EcoSystem Management Project



Fire treatments & characteristics

- **Fire treatments**
  - **Fell and burn**
    - Cut in Jun-Aug 1990 with no merchantable products removed, prescribed-burn in Sept 1990 (growing season burn), planted with P. strobus in Feb-Mar 1991 at wide spacing to allow pine/hardwood mixture (Swift et al. 1993).
  - **Restoration burn**
    - Prescribed-burn in Apr 1995 (spring before leaf out), ignited by helicopter at the bottom of a south-facing slope, creating a mosaic of fire intensities similar to wildland fire (Vose et al. 1999).
- **Fires characteristics**
  - **Fell and burn;**
    - Intensity; peak flame temperatures ranged from 630 to > 800 °C with uniform effects across the stand
    - Severity; heat penetration was 37-44 mm at 60 °C, flame duration was short, lasting <2 min. in the slash
  - **Restoration burn;**
    - Intensity; peak flame temperatures ranged from 80 to >800 °C, resulting in a mosaic of fire intensities
    - Severity; heat penetration to forest floor varied across slope positions (24-27 mm on ridge; 17-18 mm at mid-slope; <0.6 mm at low-slope)

Objectives

- **Effects of fire on:**
  - Forest floor mass, carbon and nitrogen (Vose et al. 1993, Clinton et al. 1996, Vose et al. 1999)
  - Soil nutrients and stream chemistry (Knoepp & Swank 1993, Vose et al. 1999)
  - Vegetation (regeneration, diversity, forage production) (Elliott et al. 1999, Clinton et al. 2000)
  - Pine germination and establishment (Elliott et al. 1999)
  - Stand structure (Hendrick et al., UGA)
  - Forest floor insects (Crossley & Lamoncha 1999, UGA)
  - Small mammals (Ford et. al. 1999, UGA)
  - Stream sediment and soil erosion (Swift et al. 1993, Swift et al.)

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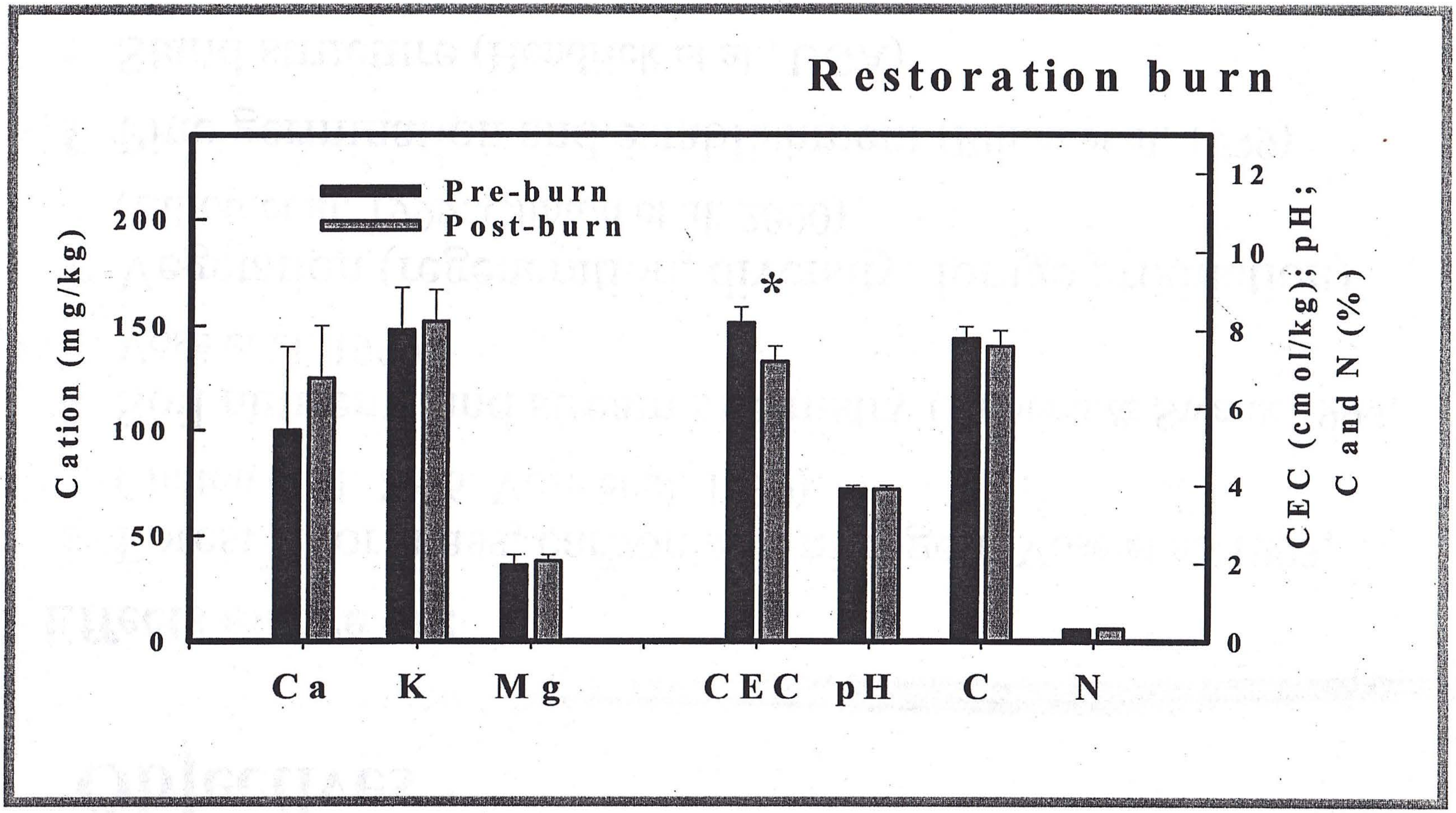
Soil chemistry responses to burning



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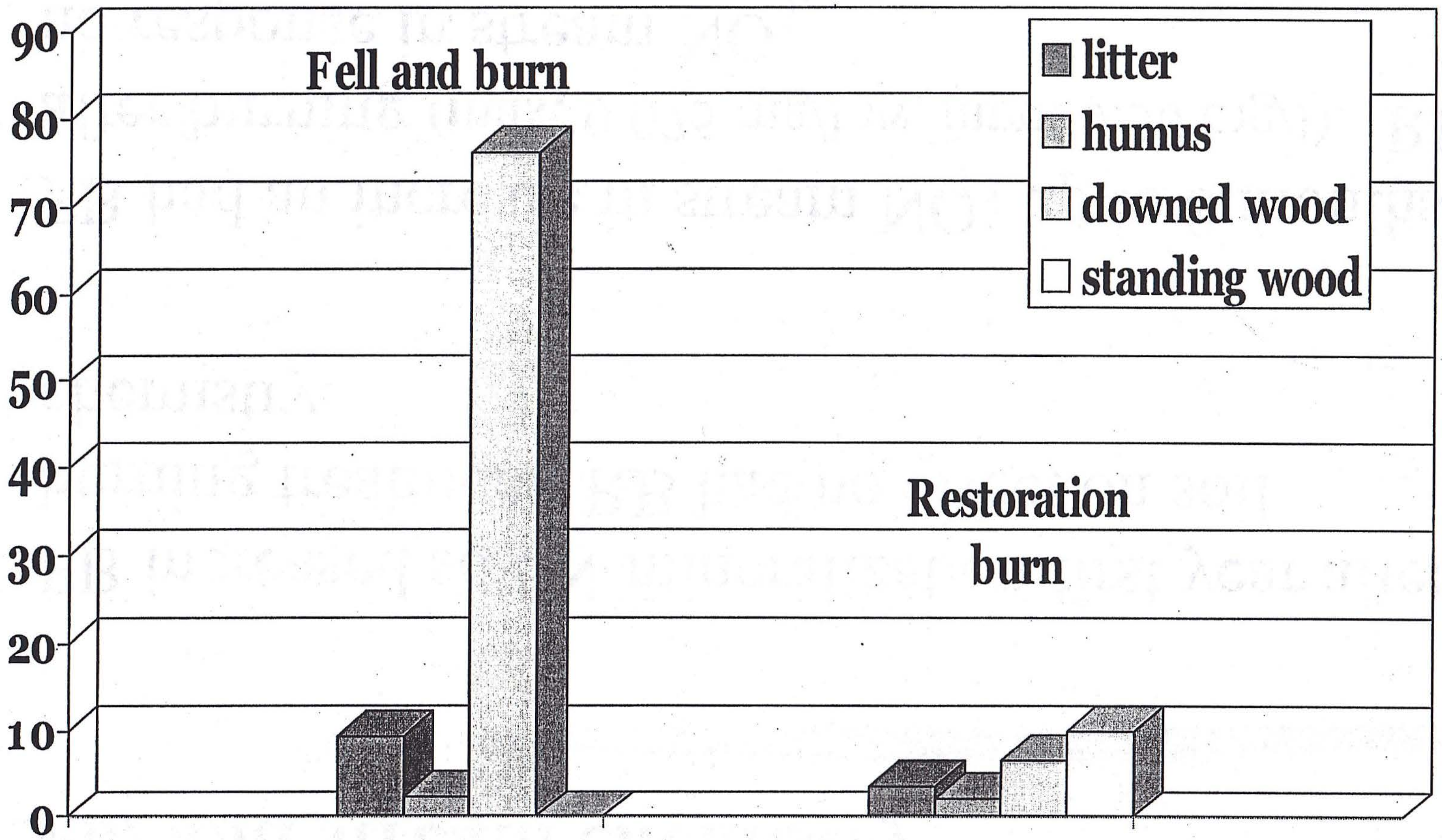
Soil and stream chemistry

- FB increased soil N-mineralization first year after burning treatment; RB had no effect on soil chemistry.

- FB had an increase in stream NO_3 up to 8 months after burning (max. 0.075 mg/l *vs*. input 0.30 mg/l). RB no response in stream NO_3.

Mass loss (Mg/ha)



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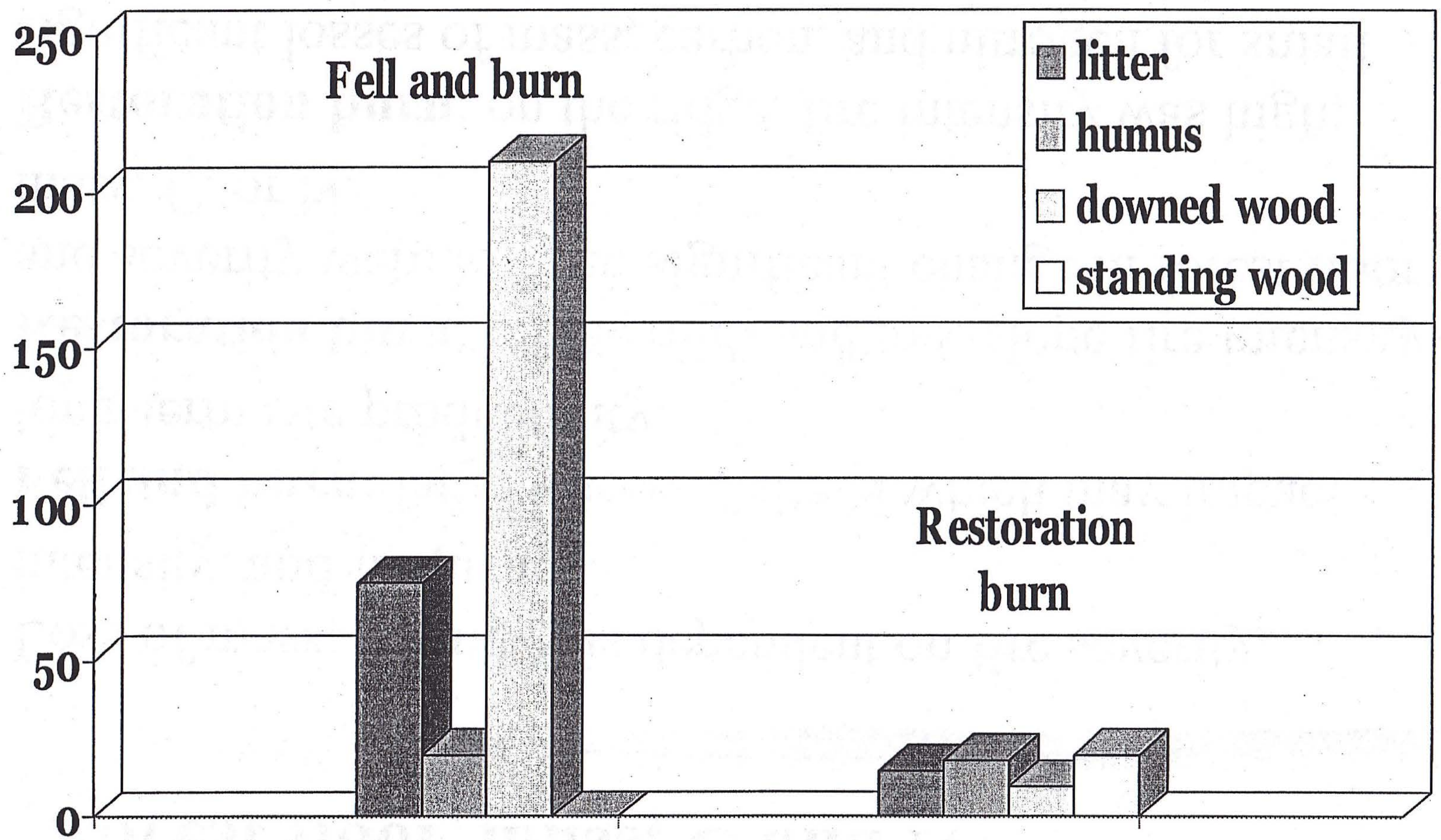
Nitrogen loss (kg/ha)



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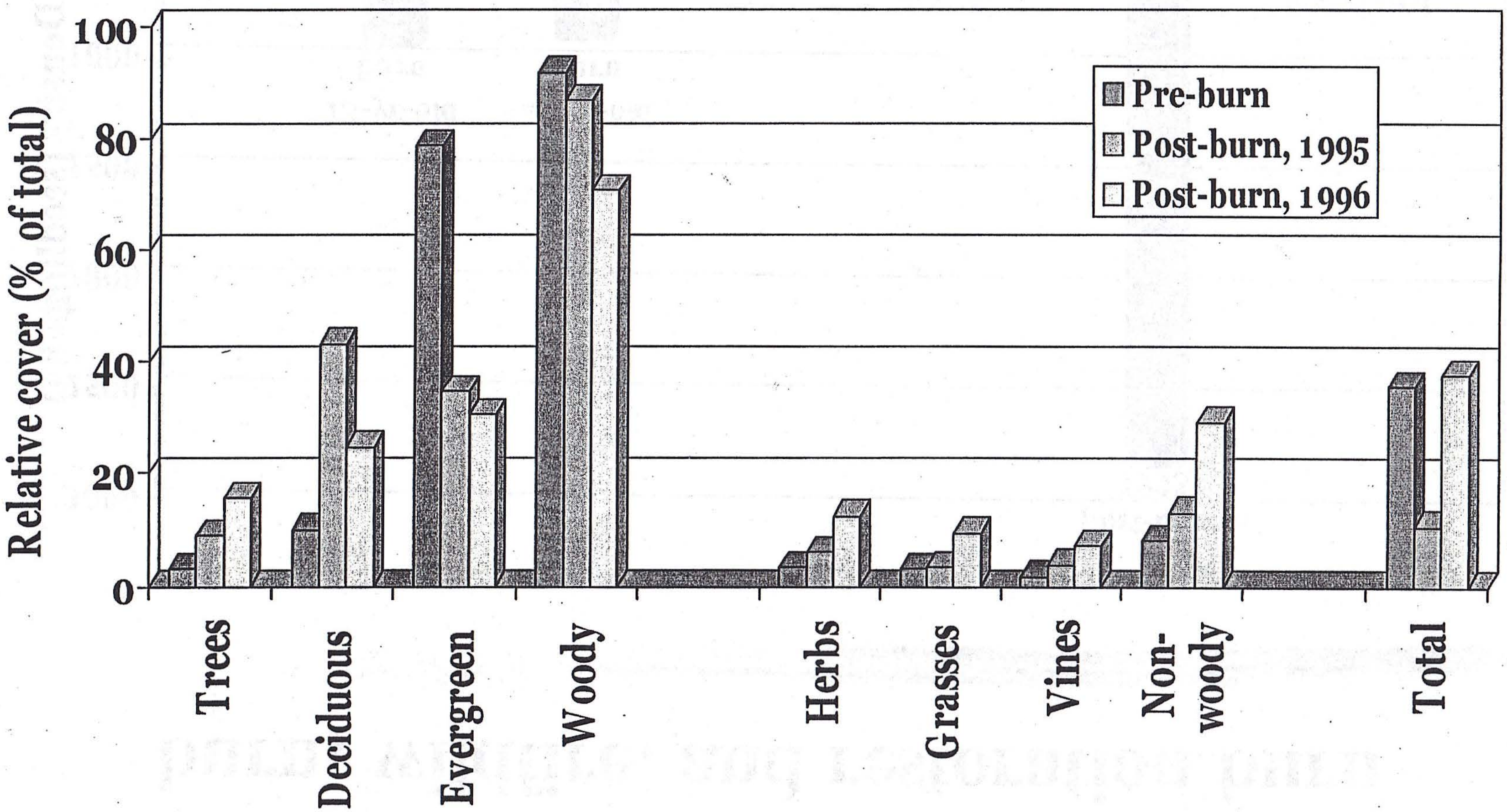
Forest floor mass, C and N

- Loss of mass, C, and N is dependent on fire severity, intensity, and frequency.
- **Fell and burn**; large losses of site N which may impact long-term site productivity.
- **Restoration burn**; on the mid- and low-slope fire intensity and severity were low; no significant change in forest floor mass, C, or N.
- **Restoration burn**; on the ridge, fire intensity was high; significant losses of mass, carbon, and nitrogen for small wood and litter.

Restoration burn: relative percent cover by growth form of herb-layer vegetation



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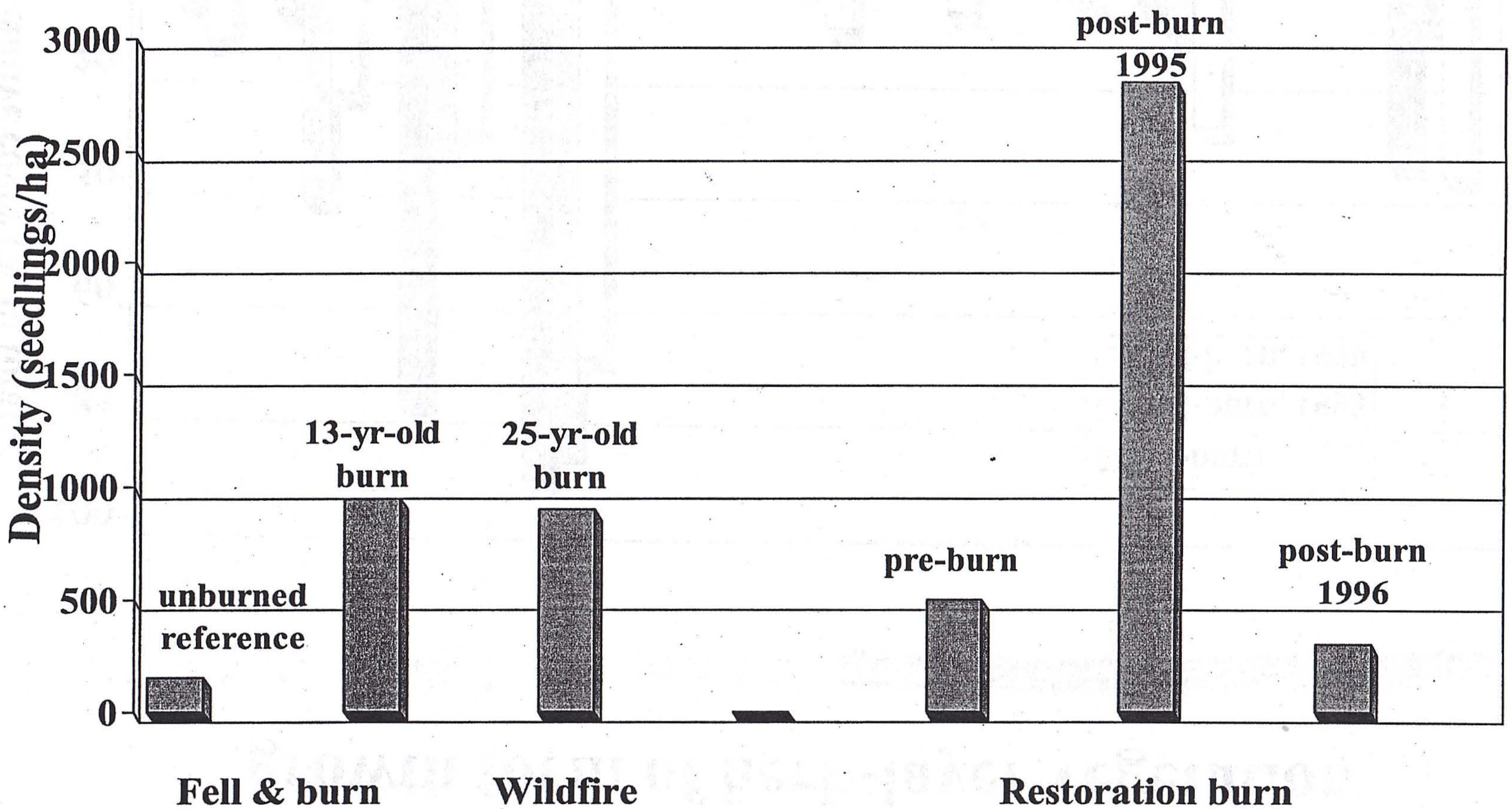
Pine seedling + sapling response to fell & burn, wildfire, and restoration burn



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Vegetation

Fell and burn

- Species diversity did not increase until 4 yrs after burning
- Yellow pine component increased 1-4 yrs after burning
- K. latifolia was substantially reduced, while Vaccinium, Gaylussacia, Rubus, and Robinia (a nitrogen-fixer) increased.

Restoration burn

- Fire had varying effects on species richness and diversity across the hillslope gradient.
- Although P. rigida germinated prolifically, by 1996, most of these germinants died and seedling numbers were less than pre-burn.
- K. latifolia was reduced, while other genera such as Vaccinium, Gaylussacia, Rubus, and Robinia increased.

Small mammals and insects (restoration burn)

- There was little or no change in small mammals or herpetofauna after burning.
- Groups of microarthropods responded differently to the burning treatment.
  - Prostigmata (small and delicate forms) <50% of preburn
  - Mesostigmata (robust predators)- little reduction
  - Collembolas (opportunistic species) - increased
  - Oribatid mites numerous and species rich (110) - numbers were reduced, 22 species lost

Management Implications

- **Restoration Burn (RB) vs. Fell and Burn (FB)**
- **RB** creates a mosaic of effects
  - resulting in mix of species comparable to wildfire derived communities
- **RB** lower site N losses than **FB**
- **RB** lower cost to implement than **FB**
- **RB** less native pine regeneration than **FB**
- **RB & FB** increased oak regeneration
- **RB & FB** increased forage production (soft-mass, berries)
- **RB** a more difficult prescription to apply than **FB**
- **RB** more limited opportunity for additional management (e.g., product removal and planting) than **FB**

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- Elliott, K.J. & Vose, J.M. 1993. Site preparation burning to improve southern Appalachian pine-hardwood stands: photosynthesis, water relations, and growth of planted Pinus strobus during establishment. Can. J. For. Res. 23:2278-2285.
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- Clinton, B.D., Vose, J.M. & Swank, W.T. 1996. Shifts in aboveground and forest floor carbon and nitrogen pools after felling and burning in the southern Appalachians. For. Sci. 42:431-441.
- Clinton, B.D., Vose, J.M., Swank W.T., Berg, E.C. & Loftis, D.L. 1998. Fuel consumption and fire characteristics during understory burning in a mixed white pine-hardwood stand in the southern Appalachians. USDA For. Serv. Res. Paper SRS-12.
- Clinton, B.D. & Vose, J.M. 2000. Plant succession and community restoration following felling and burning in the southern Appalachians. Proceedings of the 21st Tall Timbers Fire Ecology Conference, April 13-16, 1998, Tallahassee, FL.
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- Elliott, K.J. & Vose, J.M. 1994. Photosynthesis, water relations, and growth of planted Pinus strobus L. on burned sites in the southern Appalachians. Tree Physiol. 14:439-454.
- Elliott, K.J. & Vose, J.M. 1995. Evaluation of the competitive environment for white pine (Pinus strobus L.) seedlings planted on prescribed burn sites in the southern Appalachians. For. Sci. 41:513-530.
- Elliott, K.J., Hendrick, R.L., Major, A.E., Vose, J.M. & Swank, W.T. 1999. Vegetation dynamics following stand-replacement fire in the southern Appalachians. For. Ecol. Manage. 114:119-213.
- Elliott, K.J., J.M. Vose, & W.T. Swank. 2000. Fire as a silvicultural tool to improve southern Appalachian Pine-hardwood stands. Proceedings of the 21st Tall Timbers Fire Ecology Conference, April 13-16, 1998, Tallahassee, FL.
- Ford, W.M., McGill D.W., Laerm, J. Meszel, M.A. & McCay T.S. 1999. Effects of a community restoration fire on small mammals and herpetofauna in the southern Appalachians. For. Ecol. Manage. 114:233-243.
- Neary, D.G. & Currier, J.B. 1982. Impact of wildfire and watershed restoration on water quality in South Carolina's Blue Ridge Mountains. S. J. Appl. For. 6:81-90.
- Vose, J.M., Swank, W.T. & Clinton, B.D. 1994. Fire, drought, and forest management influences on pine/hardwood ecosystems in the southern Appalachians. In Proceedings of the 12th Conference on Fire and Forest Meteorology, October 26-28, 1993. Jekyll Island, GA. pp. 232-238.
- Vose, J.M. Swank, W.T., Clinton, B.D., Hendrick, R., Major, A.E. 1997. Using fire to restore pine/hardwood ecosystems in the Southern Appalachians of North Carolina. In: Fire effects on threatened and endangered species and habitats: Symposium proceedings; 1995 November 13-16; Couer de Alene, ID; International Association of Wildland Fire, Spokane, WA: pp. 1-6.
- Vose, J.M., Swank, W.T., Clinton, B.D., Knoepp, J.D. & Swift L.W., Jr. 1999. Using stand replacement fires to restore southern Appalachian pine-hardwood ecosystems: effects on mass, carbon, and nutrient pools. For. Ecol. Manage. 114: 215-226.
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Wine Spring Creek

Changes in plant diversity with three types of regeneration methods in the southern Appalachians

Treatments:

Shelterwood cut -- residual basal area; average 7.5 m^2/ha (33 ft^2/ac)

Irregular shelterwood cut (two-age) -- residual basal area; average 3.7 m^2/ha (16 ft^2/ac)

Group selection -- 0.1 to 0.2 ha openings ~ 25% overstory removal by area;
average 19.8 m^2/ha (85 ft^2/ac)

Control – uncut area; average 31.1 m^2/ha (135 ft^2/ac)

Site selection: (completed July 1993)

Each treatment was repeated three times across the landscape in similar Landscape Ecosystem Classification units (McNab and Browning 1992)

Community: Dry, high elevation red oak (*Quercus rubra*)
- Elevation – 1340 – 1460 m
- Precipitation – 180 cm annually
- Topography – broadly rounded summits
- Soil moisture – dry or between xeric and mesic
- Understory – deciduous shrubs, predominately flame azalea (*Rhododendron calendulaceum*)

Schedule

Sites traversed, overstory description (Bill Culpepper – Feb. –Mar. 1994)

Pre-treatment:
- Plot establishment (Elliott – March 1994)
- Vegetation sampling (Elliott – May (overstory); June-July (herbaceous) 1994)
- Soil sampling (Knoepp -- Winter 1995)
- Soil type description (Browning -- 1995)
- Regeneration of tree cohorts (Loftis -- 1994)

Harvest treatments; spring-summer, 1996

Post-treatment:
- Vegetation sampling (Elliott – June-July (herbaceous) 1998, 2000; Oct-Nov. (overstory) 1998)
- Soils sampling (Knoepp – Winter 1998, 2000)
- Regeneration of tree cohorts – (Loftis – 2000)

WINE SPRING CREEK -- Regeneration harvests study.

Table 1. Importance values of the dominant overstory species in each regeneration treatment in pre-cut (1994) and post-cut (1998).

	Importance Values = (relative density + relative basal area)/2							
	Shelterwood		Two-age cut		Group Selection		Control	
Species	1994	1998	1994	1998	1994	1998	1994	1998
Acer rubrum	27.2	11.5	32.9	34.6	35.9	29.0	17.0	17.3
Quercus rubra	14.5	32.1	13.8	17.5	15.7	18.2	51.6	49.6
Quercus prinus	13.3	24.0	16.0	31.4	8.9	7.0	--	--
Quercus alba	1.8	3.2	--	--	10.6	12.0	11.0	11.3
Carya spp.	7.9	6.0	0.3	1.1	2.5	3.3	0.4	0.4
Hammamelis virginiana	1.8	--	6.2	0.7	8.0	8.2	6.2	6.7
Halesia carolina	8.8	3.0	8.1	1.3	1.3	0.0	0.2	0.2
Fagus grandifolia	--	--	5.2	0.0	1.0	0.3	0.1	0.0
Tsuga canadensis	1.9	5.0	3.0	7.2	3.8	9.0	0.2	0.2
Amelanchier arborea	0.8	2.2	4.4	4.2	1.8	2.6	6.9	7.4
All oaks	29.6 %	59.3 %	29.8 %	48.9 %	35.2 %	37.2 %	62.6 %	60.9 %

Table 2. Average density, basal area, diversity (H'), and richness (S) of overstory trees pre-cut (1994) and post-cut (1998).

	Shelterwood		Two-age cut		Group selection		Control	
	1994	1998	1994	1998	1994	1998	1994	1998
Density (stems/ha)	1009	113	1088	86	1089	742	800	858
Basal area (m^2/ha)	28.2	9.1	26.8	5.7	26.2	19.8	27.8	31.1
H'density	1.89	1.32	1.81	1.16	1.79	1.68	1.59	1.62
H' basal area	1.70	1.19	1.53	1.01	1.56	1.46	1.20	1.25
S (richness)	16	9	17	6	18	15	10	10

Table 3. Average density, percent cover, diversity (H'), and richness (S) of herbaceous-layer pre-cut (1994) and post-cut (1998, 2000).

	Shelterwood			Two-age cut			Group selection			Control		
	1994	1998	2000	1994	1998	2000	1994	1998	2000	1994	1998	2000
Density (plants/m^2)	211	260	157	217	175	149	174	162	159	263	235	159
Cover (%)	99	122	138	91	91	119	83	103	121	134	111	112
H'density	2.38	2.26	2.70	2.11	2.40	2.37	2.71	2.26	2.42	2.12	1.66	1.92
H' cover	3.17	3.64	3.55	2.94	3.52	3.33	3.36	3.61	3.54	2.97	3.26	3.22
S (richness)	63	61	65	54	56	55	65	63	64	60	53	48

Table 4. Percent cover of most abundant herbaceous-layer species pre-cut (1994) and post-cut (1998) and (2000).

	Percent cover		
Shelterwood	1994	1998	2000
Gaylassacia ursina	11.88	1.88	7.71
Thelypteris noveboracensis	8.54	12.60	12.75*
Galax aphylla	8.44	4.79	7.19
Prenanthes trifoliolata	6.36	3.64	2.19
Viola hastata	4.38	4.27	2.08
Solidago curtisii	3.65	4.38	3.54
Smilax spp.	2.72	3.02	5.60
Carex spp.	2.31	3.33	3.85
Rhododendron calendulaceum	2.19	2.62	2.08
Melampyrum lineare	2.19	2.08	1.56
Dennstaedtia punctilobula	1.05	2.08	5.27*
Two-aged shelterwood			
Gaylassacia ursina	19.27	3.89	10.49
Prenanthes trifoliolata	9.94	3.82	1.94
Medeola virginiana	4.66	3.30	3.85
Viola hastata	4.52	3.54	1.52
Thelypteris noveboracensis	4.45	5.31	10.42*
Carex spp.	3.94	6.08	8.78
Dennstaedtia punctilobula	0.74	1.70	2.67
Vaccinium corymbosum	1.08	0.87	5.45
Ligusticum canadense	2.99	1.56	3.16
Galax aphylla	2.78	1.67	3.61
Group selection			
Thelypteris noveboracensis	11.46	17.50	19.69*
Gaylassacia ursina	4.90	1.14	2.29
Viola hastata	4.38	3.02	1.77
Prenanthes trifoliolata	3.96	2.71	2.08
Smilax spp.	3.66	2.71	3.44
Solidago arguta	3.03	2.60	3.40
Melampyrum lineare	2.61	2.29	1.25
Rhododendron calendulaceum	2.51	1.77	2.10
Carex spp.	1.99	3.85	8.02
Anemone quinquifolia	1.98	1.04	1.25
Control			
Thelypteris noveboracensis	38.64	27.60	25.88*
Carex spp.	9.33	7.44	7.29
Dennstaedtia punctilobula	7.04	2.14	2.27
Rubus allegheniensis	5.99	3.02	2.24
Solidago curtisii	5.53	4.17	4.54
Ligusticum canadense	5.00	3.38	7.29
Viola hastata	4.32	1.72	1.67
Anemone quinquifolia	4.01	2.29	1.88
Prenanthes trifoliolata	3.65	1.77	3.07
Dioscorea villosa	3.29	3.28	4.53

Summary of studies completed or in progress on the Wine Spring Creek Ecosystem Management Project

(Title, Investigator, Affiliation, & Status)

1. Survey of potential endangered and threatened species and National Heritage areas in the Wine Spring Creek watershed. Dan Pittillo and Bob Dellinger, Western Carolina University, Completed

2. An ecological classification and inventory system on the Wayah District. Henry McNab, SEFES, Bent Creek; Steve Simone, NFS, Asheville; and Sally Browning, NFS, Franklin, Phase I Completed; Phase II Initiated

3. Stable isotopic assessment of the status and prehistoric vegetation of Southern Appalachian balds. Larry Tieszen, Augustana College and Jennifer Knoepp, SEFES, Coweeta Hydrologic Laboratory, Manuscript Preparation

4. Impact of land-use practices on aquatic biota. Bruce Wallace, Judy Meyer, Deborah Wohl, and John Hutchins, University of Georgia, Phase I Completed; Phase II Initiated

5. Effects of timber and wildlife management on neotropical migratory birds in the mountains of western North Carolina. David Guynn and Robert Katz, Clemson University.

6. Effects of timber and wildlife management on wild turkeys in the mountains of western North Carolina. David Guynn and Craig Harper, Clemson University, In Progress

7. Brook trout genetics. Pat Flebbe, SEFES, Blacksburg, VA, (Coop. with Eric Hallerman and Brian Borkholder, VPI and State V. Blacksburg, VA.), Completed

8. Quantification of fish populations in Wine Spring Creek watershed. Pat Flebbe, SEFES, Blacksburg, VA, In Progress

9. Characterization and mapping of large woody debris in Wine Spring Creek watershed. Pat Flebbe, SEFES, Blacksburg, VA (coop with Dr. Craig Hedman), Completed

10. Modification, application, and validation of wildland sediment model to Wine Spring Creek watershed. Lloyd Swift, Steve McNulty, and Wayne Swank, SEFES, Coweeta Hydrologic Laboratory, In Progress

11. Characterization of precipitation and stream chemistry in Wine Spring Creek watersheds. Wayne Swank, SEFES, Coweeta Hydrologic Laboratory, In Progress

12. Social and amenity values and issues in ecosystem management: Wine Spring Creek Project. Ken Cordell and Christene Overdevest, SEFES, Athens, GA, In Progress

13. Development and application of a nutrient cycling model to assess sustainable productivity for silvicultural alternatives. Jim Vose, Jennifer Knoepp, and Wayne Swank, SEFES, Coweeta Hydrologic Laboratory, In Progress

14. Investigations into *Rhododendron maximum* and its ecological roles in southern Appalachian riparian zones. David Van Lear and Terrell Baker, Clemson University, Nearing Completion

15. Changes in plant diversity with four types of regeneration in the southern Appalachians. Katherine Elliott, SEFES, Coweeta Hydrologic Laboratory, In Progress

16. Climatology in the Wine Spring Creek Watershed. Lloyd Swift, SEFES, Coweeta Hydrologic Laboratory, In Progress

17. Modeling regeneration responses under a range of regeneration alternatives. David Loftis, SEFES, Bent Creek, In Progress

18. Preliminary classification of humus forms in the Wine Spring Creek Watershed. Henry McNab, SEFES, Bent Creek, Phase I Completed

19. Application of an ecological landscape classification model for the identification of Carolina Northern Flying Squirrel (*Glaucomys Sabrinus Coloratus*) habitat in the WSC Watershed. Richard Odom, Jr., Haywood Community College, Clyde, NC, In Progress

20. Economic analysis of ecosystem management: A case study for the Wine Spring Creek Project. Robert Abt and Rex Schaberg, NC State University, In Progress

21. Wine Spring Creek bedload sediment transport measurements and modeling. Todd Rasmussen and Russell Royston, University of Georgia, In Progress

22. The effects of high-intensity fires on oak-pine communities in the Southern Appalachians. Ron Hendrick and Amy Major, University of Georgia, In Progress.

23. Response of small mammal communities to alternative regeneration harvests in Wine Spring Creek watersheds. Winston Smith and Mark Ford, FS (SREL).

24. The effects of prescribed fire on small mammal communities. Winston Smith and Mark Ford, FS (SREL).

25. Baseline economic conditions near the Wine Spring Creek watershed. Don English, FS (Athens).

26. Effects of uneven/aged management and prescribed burning on edaphic arthropods. D.A. Crossley, Jr., University of Georgia.

27. Fire characterization, forest floor, soil, vegetation and water quality responses to stand restoration burning.